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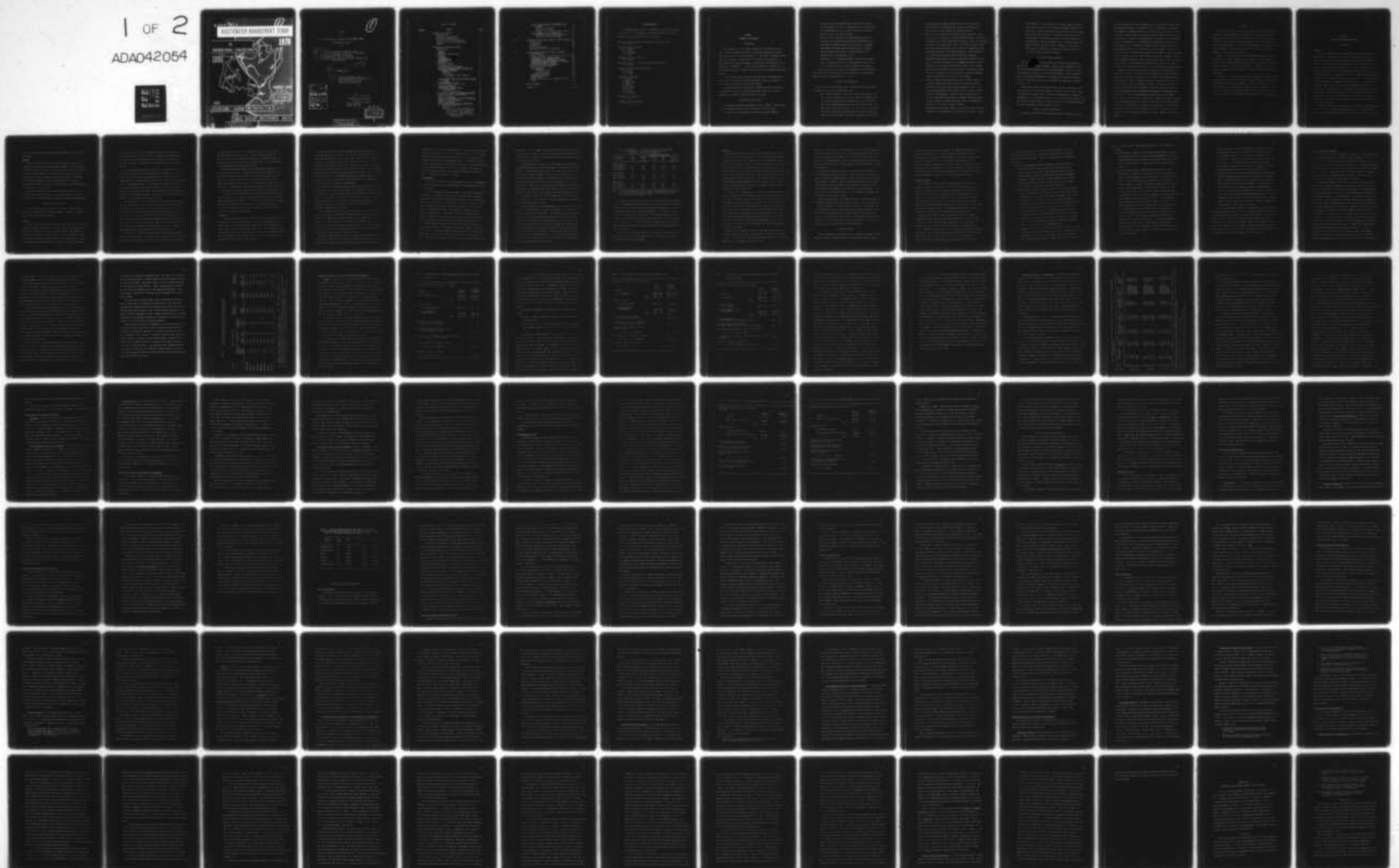

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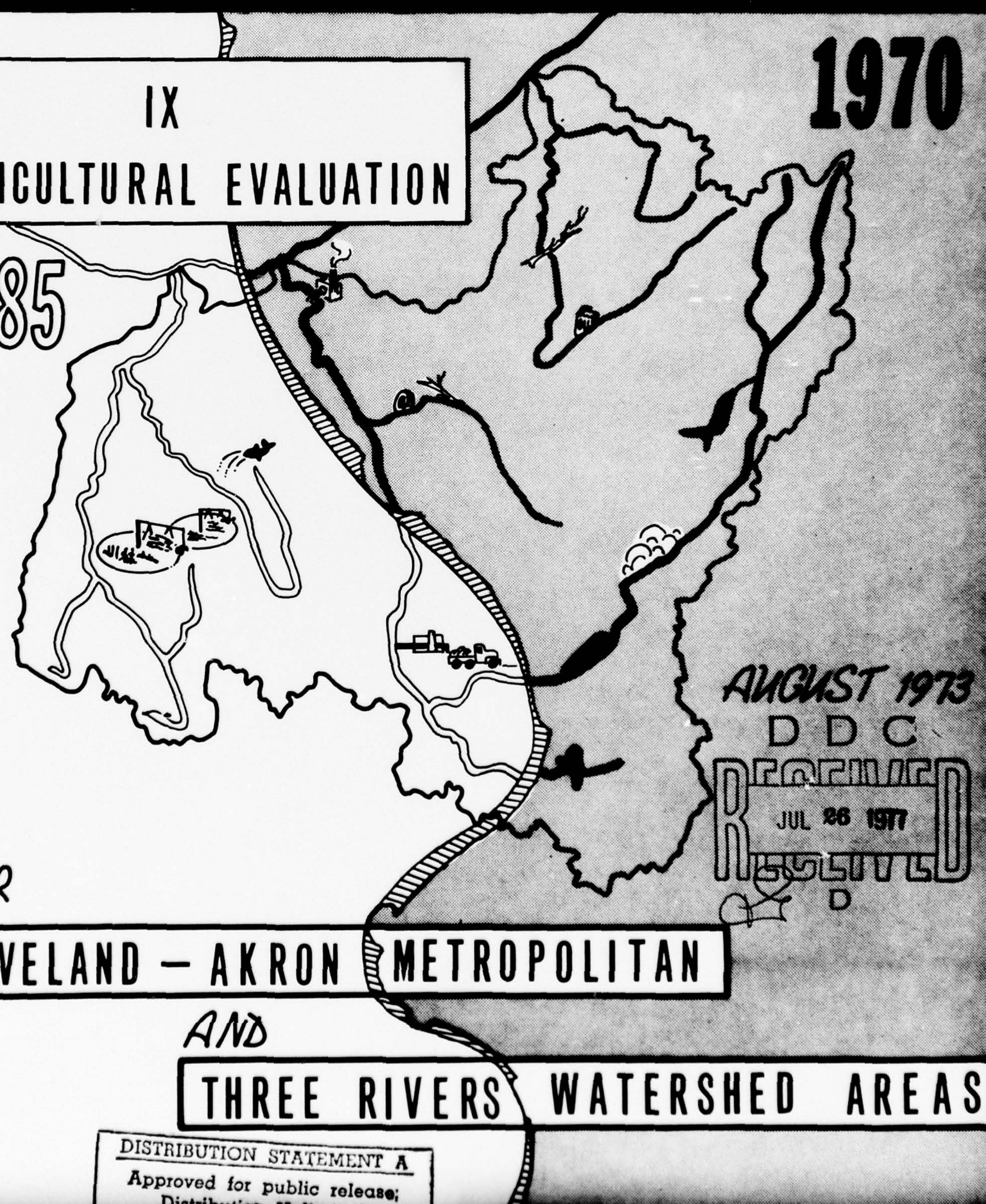

AUGUST 1973

FOR

CLEVELAND - AKRON METROPOLITAN

AND

THREE RIVERS WATERSHED AREAS

(1)

REPORT

OF

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER

WASTEWATER TASK FORCE

by

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(12) 136p.

(11) 31 July 31, 1973

(6) Wastewater Management Study for Cleveland-Akron Metropolitan and Three Rivers Watershed Areas. ~~IX.~~ Agricultural Evaluation

(15)

Contract DACW 49-73-C-0170 new
for
U. S. Army Corps of Engineers
Buffalo District
Buffalo, New York

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ACKNOWLEDGEMENTS:

In addition to the authors, the following individuals contributed significantly in the development of the Ohio Agricultural Research Development Center, Wastewater Task Force Report.

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CHAPTER I

SUMMARY OF EVALUATION

Introduction

In mid-March, 1973, the College of Agriculture and Home Economics at The Ohio State University and the Ohio Agricultural Research and Development Center agreed to contract with the U. S. Army Corps of Engineers, Buffalo District, to conduct a critical review of the feasibility studies and reports related to alternate wastewater treatment plans for the Three Rivers Watershed (See Appendix A). This review considered the agricultural, environmental, social and economic impacts on the rural and farming communities involved.

In this section summary statements are given first concerning evaluation of consultant reports which are addressed in detail in Chapter II. A brief summary of Chapters III and IV then follows.

The research committee examined the consultant reports on wastewater management from five major subject matter areas. These are as follows: engineering, agronomic, wildlife, economic and social.

Engineering Considerations

In reviewing the Wastewater Management Study, Appendix V, from an agricultural engineering point of view, four major points are noted:

1. The ability of the finely textured soils selected (Mahoning-

Ellsworth and Cardington-Bennington) to receive 50 inches or more of wastewater per year is questioned due to the likelihood of a deterioration of soil structures and loss of ability to produce crops due to surface flooding.

2. The use of deep plowing to place more permeable soils in the B horizon can be expected to decrease the infiltration rate.
3. The design of drainage systems should be based on a drainage coefficient much higher than the normal 3/8 to 1/2 inch per day for mineral soils in Ohio, if field crops are to be utilized in the land treatment system.
4. The return flow of wastewaters applied to lands in the Western Basin, as proposed in Plan C, can be expected to pose serious flood risks particularly in small and medium size watersheds.

Based on the above items, Plan C, the disposal of all the wastewaters from the Three Rivers Watershed has not been shown to be an acceptable alternative from an engineering point of view.

Agronomic Considerations

The review of the consultant reports involving agronomic implications in summary result in the following conclusions:

1. The consulting engineers' decision to utilize fine-textured soils for effluent application will result in improved renovation while reducing water infiltration and permeability. It is doubtful if the proposed management practices associated with the study, e.g., deep plowing, mini-border concept, etc., will result in sufficient improvement in physical properties and allow for the rapid infiltration of 75 to 90 inches of effluent. Intermittent periods of

soil saturation and reduced aeration in the root zone may limit plant growth and ion renovation and provide the main restraint to the success of the proposed land treatment systems.

2. The degree of nitrogen renovation provides the second most serious constraint to the success of the land treatment systems. Application rates should be related to the amount of nitrogen which will affectively be removed by the higher plant. The risk of excess nitrate nitrogen above plant needs is greater with corn than with a management system using Reed Canarygrass. The proposed plans do a rather acceptable job in providing the desired degree of nitrogen renovation.

3. Heavy metal accumulation provides the long term restraint for using soils for effluent renovation. If no attempts are made to remove most metals at the industrial site, toxic levels of zinc, nickel, and copper may accumulate in the soils within a twenty-year period. The ratio of cadmium to zinc is also much too narrow for adequate safety and could result in a hazard to food quality.

4. Little information and limited technology is presently available to assure adequate weed control in the land treatment systems. Likewise, it is not known what fungal pathogens or insect pests may become significant in crops being grown on the soils to which effluent is being applied. Periods of soil saturation with accompanying high humidity may result in unusual disease and insect problems. Methods of insect and disease control are presently inadequate for soils under constant irrigation.

5. Land application of sewage sludges to agricultural lands and strip mine spoils is an effective and economical way to dispose of these

waste materials. Application rates for sewage sludges to agricultural land as proposed in the Wastewater Management Studies could result in a potential problem with excess nitrate in the tile drainage or ground water supplies. A ten-ton/acre annual application of sewage sludge is more desirable than a 30-ton/acre application rate every third year. The environmental impact of sewage sludge applications to strip mine spoils should be positive, but application rates should be chosen which increace the beneficial effects but limit any adverse environmental problems.

Fish and Wildlife Considerations

The consideration of fish and wildlife as resources is essentially absent from consultant reports reviewed. Aquatic life is expected to benefit from the pollution abatement resulting from enactment of any of the three plans proposed in Phase III of the Consultant Reports. However, attention has not been devoted specifically to designing fish and wildlife benefits into any of the plans although it would appear that substantial opportunity exists to do so.

Significant benefits should result from (1) applying no-tillage agricultural practices to wastewater treatment land areas to reduce stream silting, (2) establishing reparian forests to stabilize stream banks and lower water temperatures, (3) reclaiming strip-mined land to provide quality wildlife habitat and reduce stream silting and acid drainage, and (4) utilizing wastewater treatment impoundments for the production of fish.

Economic and Social Considerations

Few areas of public decision-making and delivery of community services

have been proposed which are as intriguing as the large-scale sewage disposal plan with land treatment now proposed by the U. S. Army Corps of Engineers. Land treatment of community sewage holds promise for converting the nitrogen and phosphorus which remains in secondary treated effluent to beneficial use in agricultural production. Though ostensibly a beneficial and cost-reducing method of sewage disposal for the Three Rivers Watershed, the proposal as represented by Plan C (primarily all land treatment in North Central Ohio) is perplexing in terms of its economic and social acceptance as well as its control by public intervention and provision of the sewage service. The main areas for concern are, first, farm practices would have to change from high return intensive production to more extensive lower return production and such a move will not be done without either artificially high fees for land use or artificially high prices of forage as it is converted into beef production.

Second, we cannot infer agricultural benefits arise from increased agricultural production unless there are recognized market outlets and the additional quantities do not depress prices. Third, land treatment without land acquisition means a considerable sacrifice in the control of the disposal system. Fourth, current instruments of control (conservation and conservancy districts, metropolitan sewer districts, river basin authorities) do not have broad enough taxing and property right authority to effectively implement control of such an interregional and large-scale disposal system. Fifth, land acquisition of such a large scale required by the Plan C proposal would definitely decrease the tax base of communities with existing finance and service delivery problems. Finally, land acquisition of such a scale also imposes social costs of relocation and economic disruption which, if accounted for, would render the proposal infeasible compared to other alternatives.

Summary

The overall evaluation by the research committee indicates that land disposal with proper management is and should be a viable and acceptable alternative. However, the committee feels that the disruptive effects of an intensive land treatment system, as proposed in Plan C for the Western Basin, are unacceptable. The transmission of wastewater across basin lines may be acceptable if performed in a non-disruptive manner with respect to agronomic, economic and social factors.

Chapter III discusses extending the land treatment phase of Plan B to include all soil types, topographies and vegetative covers and applying effluent at a rate acceptable to the particular site, thus making available portions of land ruled out by the contractors. In Chapter IV aspects of design and research of land treatment for small and medium sized communities are explored.

In summary, it is emphasized that community acceptance, whether the land treatment project is relatively large or small, is paramount and rests upon the wishes or decision of the community involved. In preparing itself to make the decision, the educational approach used by the community will be critical. The decision to accept or reject, as in other community issues, should be made after full knowledge of immediate and long run consequences.

CHAPTER II

EVALUATION OF CONSULTANT REPORTS

Introduction

Purpose

This report was prepared in accordance with contractual obligations between the U.S. Army Corps of Engineers, Buffalo District, and the Ohio Agricultural Research and Development Center, Contract Number, DACW49-73-C-0170. The study covered in this report represents a critical review of numerous Reports and data (See Appendix "A") relating to the Cleveland, Akron Metropolitan and Three Rivers Watershed District areas of Ohio Wastewater Management Study, prepared for the Corps of Engineers by Consulting Contractors. This review will present an overall review of the land treatment of the wastewater management study and its environmental economical and social impact upon the rural and farming communities affected. In addition, as an integral part of this report, an alternative plan has been presented for land disposal which imparts most of the inputs of the study committee on a plan for land disposal of effluent which would be less disruptive to rural communities and therefore more acceptable as a waste treatment alternative.

Although this report deals specifically with the Three Rivers Watershed Area of Ohio and the Western Basin Disposal area, it is hoped that the discussions and critical reviews included in this report will be of value

to other regions contemplating systems of land disposal of waste effluents and sludges.

Approach

A total of twelve plans were formulated by the Consultants for consideration as alternatives for waste water management in the study area. Of these, twelve original plans, eight included land disposal of secondary effluent to varying degrees. From the original plans only three were considered for further development by the Corps of Engineers (See Phase III of Wastewater Management Study and Summary Report). Plans B & C involve land treatment of effluents and sludges and are those which received primary attention in this review.

The overall evaluation of the proposals was subdivided into the following general areas of concern: engineering, agronomic, wildlife, economic and social considerations and community perception and acceptance.

Engineering Considerations

From an agricultural engineering point of view, The Consultant's Report were reviewed under the following heading: drainage, irrigation, land management and surface hydrology.

Drainage

A major problem associated with farming in Northern Ohio is the need for improved drainage of croplands. Surface and subsurface drainage, either tile or plastic tubing, is used to solve this problem. The addition of effluent or storm runoff in amounts twice or more than the normal rainfall will decrease the number of days available for field operations. If the field operation of planting row crops is delayed, a loss of yield can be

expected, e.g., for corn about one bushel per acre per day after the optimum planting date. Drainage design is included in the Study Reports, but where row crops are grown application of effluent will need to be severely restricted or eliminated entirely during planting and harvesting periods.

The recommended drainage coefficient (rate in inches per 24 hours that water must be removed from the drained area) for mineral soils in Ohio is 3/8 to 1/2 inch. With an effluent application of 2 inches per day it is recommended that a drainage coefficient of 1 inch or larger be used depending on soil and cropping patterns. In the design of a drainage system this would mean more laterals, which the Study Reports indicate, and larger mains. The design drain spacings of 20 feet for both the Ellsworth and Cardington-Bennington soils should be adequate. Where grass cover is maintained larger diameter drains and wider spacings might be used.

The primary concern about land treatment is that effluent application rates of 50 inches and larger per year will have a deteriorating effect on the structure of fine textured soils, particularly where corn or row crops are grown. Deterioration of soil structure may be expected where saturated conditions exist even for short periods of time. At the Castalia Experimental Station on Hoytville Clay with an average of 6 inches of irrigation water applied in addition to rainfall per year, soil structure deterioration and subsequent yield depression was noted after a few years. Subsequent subsurface drainage, 20 foot spacing, has not improved the soil.

Two methods of installing drains are used: trenching (ditching) and pulling in with a mole plow. Tile and plastic tubing can be used with trenching and only plastic tubing with the mole plow. With the trenching method a

significant portion of the inflow, estimate as high as 40 to 60 percent, has been determined to infiltrate to the drains through the back fill. If this were to occur with effluent, the capacity of the back-filled soil to absorb the nutrients and metals may be reached quickly. The effectiveness of land treatment would then decrease sharply.

On the Mini Border/Open Space system the drains are designed to go in the direction of the slope. Although the 4% slope of the Mahoning is less than that which would require protective measures due to high flow velocities, drains across the slope would intercept subsurface water better. There are seepage planes on many soils due to impervious layers coming to the surface. Interceptor drains should be installed at the seep plane and at right angles to the ground water flow on the Mini Border/Open Space system.

It is noted that the Study Reports indicated that detailed planning for application rates to give proper management "will be based upon field experimental work and further analyses." It is considered essential that drainage design be based upon field testing at the various application rates. A minimum of five years of testing on the same area is considered essential before valid conclusions can be drawn.

Irrigation

The technology connected with irrigation has been developed so that the application of effluent or storm runoff to land is not considered to be a major problem. The irrigation systems proposed for the Study Report are those principally used in drier areas farther west. These systems will need to be adapted for the more humid conditions of Ohio and for the high application rates proposed. The principal system proposed is the center-pivot. Fixed sets are to be used to a lesser degree.

The principal problem that can be expected with the center-pivot system is the trafficability of the boom. It is not clear whether grass strips are planned for the wheel to roll over in all cases, e.g., 2-row corn strips. If applications are made during the Spring months, even on sod, it can be expected that the wheels will form ruts. These ruts will collect more water and eventually the center-pivot rig will become mired down. It is noted that applications of effluent may be ceased during rainy periods. This is essential in the spring months. The side-mounted flood jets, directed opposite to the direction of travel is essential to improve trafficability, because water will be placed on the land after the boom passes.

The trash-filled troughs between corn rows, with drip tubes on the rotating boom, must remain open to the surface. If they become silted over, the moisture will not enter the troughs. With high intensity rain storms in June and July, the trash-filled troughs are likely to be silted over. The grass-lined trough under the drip tube would likely be more satisfactory. As noted previously there will also be a problem of trafficability for the boom wheels unless they roll over sod.

Where alternate strips of grass and corn rows are planned with effluent applied to the grass, little lateral movement of water to the center rows of corn can be expected, which will decrease nutrient removal and water availability. The width of the corn strips should probably not be over 4-row width, to allow for the corn to take up nutrients. It is recommended that the strips of grass and corn be alternated at least every second year to permit more uniform nutrient removal by the corn.

The Mini Border/Open Space system is an adaption of the overland flow or spray-runoff system in which the water flowing over the surface infiltrates into the soil. The reports of the overland flow system used by vegetable

processors at Paris, Texas and Napoleon, Ohio, indicate that the overland flow system was fairly effective in removing nutrients. It is considered that the use of the overland flow method for storm runoff would be more suitable than the Mini Border/Open Space system. The problem of having the 150 inches per year of storm runoff to infiltrate into and move through the soil would be decreased. The use of the overland flow method with effluent and storm runoff should be researched to determine whether the Level II standard could be met in this way.

Land Management

The key to the success of any land treatment system is the management of land with respect to soils, land preparation, effluent application, and field operation.

In the Study Reports reference was made to the need for land formation and leveling in connection with the use of the center-pivot irrigation systems and with the Mini-Border/Open Space systems. It is noted that the A horizon (surface layer) is very shallow for many of the Ohio soils and for the Mahoning and Cardington-Bennington selected for land treatment. With this shallow surface layer, land forming will expose the subsoil. Because vegetative cover is essential to prevent puddling and erosion, it may be inadvisable to level land or at the least, steps will need to be taken to establish vegetative cover before effluent application begins.

The Mini-Borders proposed for overland flow method of application would present problems in maintenance and equipment movement. The concept is valid and it is suggested that the ridges (borders) have side slopes equal to or flatter than a ratio of 4:1 dependent upon the equipment to be used. This will allow equipment to move over the fields without destroying

the borders. It will, however, decrease the effective filtering and infiltration areas. It might be desirable to use low pressure spray irrigation in place of flood irrigation on the upper portion of the slopes as reported in the spray-runoff systems.

It appeared that the authors of the Study Report are fascinated with deep plowing and believe it would work wonders in increasing the soil permeability. They noted that the practice is currently being used in the plains region of Western Canada. This region uses "dry-land" farming. It has been the consistent evaluation of both agricultural engineers and soil scientists that deep plowing will not improve permeability of the fine-textured soils in Ohio and in fact would likely decrease the infiltration by bringing less permeable clays to the surface. The use of deep plowing to bring calcium-rich soil to the surface and reduce the need for liming is not applicable to Ohio soils. The estimated cost of $10-15 per acre for deep plowing is too low for Ohio. Also, the equipment for deep plowing is not generally available in Ohio.

The days available for field operations are very limited for Ohio conditions. The days available to plow, till or plant in Ohio, Table 1, is presented at the end of this section. This table for soils in different drainage groups indicates that on the average (50% of the years) days available for field operation in March and April are very limited. The effect of additional water on the land will decrease the available days. In light of these facts, two options are open: do not row crop so that tillage operations are not needed, or if row crops are used, eliminate irrigation during wet spring months prior to planting and during harvest periods. Generally, one week of dry weather preceding field operations is needed for spring months field operations.

Table I. Days Available for Final Seed Preparation and Planting Corn and Soybeans by Selected Periods and Drainage Conditions, Central Ohio, 1938-1957*

Drainage and Period	Total Days	Favorable Days Available: Average for Period	Worst Year	Best Year	Minimum 16 out of 20 Years
Average Drainage					
May 6-June 5	31	13.5	7.0	21.0	10.0
May 11-May 31	21	8.5	2.0	18.0	5.0
May 16-June 10	26	11.5	4.0	17.0	9.0
Poor Drainage					
May 6-June 5	31	11.5	4.0	21.0	7.0
May 11-May 31	21	7.5	1.0	17.0	3.5
May 16-June 10	26	9.5	1.0	17.5	6.5
Good Drainage					
May 6-June 5	31	15.0	9.5	21.0	12.0
May 11-May 31	21	9.5	3.5	19.0	6.5
May 16-June 10	26	12.5	6.5	20.0	11.5

*From: "The Effect of Weather on Days Available to do Selected Crop Operations," A.E. Bulletin 313, Department of Agricultural Economics and Rural Sociology, Ohio State University, 1960.

A problem of soil cracking may arise when fine-textured soils are allowed to dry. This phenomena has been observed on the drainage plot at the Castalia Research Station. Higher sediment concentrations were observed in the tile drainage water than in the surface drainage water. If this were to occur with effluent applications, the purpose of land treatment would be voided. The effluent would flow through these cracks directly into the drains without filtering into the soil. The use of continuous grass cover will minimize this problem by allowing field operations at higher soil moisture conditions, prior to cracking.

Farming in circles has been proposed in connection with the center-pivot irrigation system. From a technology and use of equipment point of view this should not present any problems.

Hydrology

The sections on surface hydrology in the Study Report refer primarily to the western land treatment areas. It was estimated that the maximum wastewater return flow for the Sandusky, Huron and Vermilion Rivers was two to four times greater, based on flow per unit area (csm - cubic feet per second per square mile of watershed) than the average annual flow. The maximum potential return flow was estimated to be less than 17% of the mean annual flood flow (the flood recurring every 2.33 years--representing the channel capacity without overtopping). These calculations are for large watersheds and the Study Reports state that "the western land treatment areas...are considered to be feasible for wastewater disposal from the standpoint of surface hydrology."

This assertion is questionable. In Table VI-9, the Annual Average Flow, The Maximum Potential Wastewater Return and The Mean Annual Flood Flow for rivers in the Western Basin are presented. The flows are given in (cfs). Using area of the river watershed, from Table VI-7, the csm values were calculated. The flow for the Maximum Potential Wastewater Return varies from 1.5 to 3.5 csm. An assumption of 14 cfs per 1000 acres (9 csm) was used to determine the Maximum Potential Wastewater Return Flow, which corresponds to a drainage coefficient of 3/8 inch per acre for 24 hours (10 csm). The wastewater return flow was calculated to be 1/3 to 1/6 of the assumed value, which is possible allowing for land in watershed not being used for disposal.

However, as noted under the section on Drainage in this critique, a drainage coefficient (inches of drainage water per 24 hours for an area) of about 1 inch per day or larger would be needed to handle a 2-inch-per-day application. A drainage coefficient of 1 inch

would give a flow of 27 csm. This flow value is larger than the Mean Annual Flood Flow for the rivers noted. All of the watershed acreage would not be used as a disposal site, but where a significant percentage of small and medium size watershed acreage is used, the wastewater return flow alone could conceivably cause flooding if a large portion of the watershed was irrigated simultaneously.

Harrold (1961) established that the runoff from small watersheds in Ohio was greatest during the months of June and July due to localized convectional type storms (thunderstorms). This is during the period that wastewater disposal is planned. Because of the unpredictable nature of convectional storms, which in themselves can cause flooding, and the potential for flooding from wastewater return flow, Plan C is not recommended. The improvement of low flow conditions due to land disposal of wastewater will not outweigh the loss due to flooding.

Besides flood potential, the larger base flow of streams and rivers will increase stream bank erosion and sediment transport. This is undesirable.

The use of lands in the Western Basin for disposal of wastewater from local municipalities could be considered as an alternate treatment method with respect to surface hydrology. Drinking water originates from the rivers or ground water and land disposal of in-basin wastewater would return water to the supply. Consideration would need to be given in selection of a disposal site to minimize flooding of small watersheds.

Agronomic Concerns

Effluent renovation by land application is a highly significant concept which must remain a viable alternative to conventional chemical, physical

and biological waste treatment processes. Yet, while considering its value, everyone concerned with soil renovation systems must be aware of their limitations and the need for proper management to assure long term success. Failure to do so carries with it the hazard of severe damage to water resources, valuable land resources, and public health. Agronomic principles (both crop and soil management) are of utmost importance to successful waste renovation by soils. The following paragraphs will evaluate the Wastewater Survey Study Reports in light of the significant agronomic aspects.

Selection of soils

Soil properties (physical, chemical and biological) are extremely important to wastewater renovation. Often soil selection has been based solely on water infiltration rate and soil permeability, while ignoring the role of soil colloids in the renovation processes themselves. For this reason it is both refreshing and valid for the consultants to alter soil selection criteria to include finer textured soils with greater adsorptive capacity and subsequent renovative capacities. Unfortunately, this decision has resulted in the selection of soils (Cardington-Bennington; Mahoning-Ellsworth) with rather poor infiltration and internal drainage.

Agronomy staff members who have reviewed this report are unanimous in expressing a concern that the soils chosen (except the Chili) will become saturated for long time periods when irrigated with 75 to 90 inches of secondary effluent. They do not feel that different management systems e.g. Mini Border/Open Space System or tile drainage will completely alleviate the problem. Many of these concerns have been expressed in the Agricultural Engineering section of this report, and will not be reviewed here. In addition the following points have been raised concerning the proposed

The following comments are concerned with other properties of these till derived soils which might reduce their applicability for renovating large quantities of waste water. They are included here for consideration and evaluation.

a) On a microtopographic scale the surface of soils even on nearly uniform slopes have surface relief of the dimensions of 6 to 12 inches. Thus, any leveling or shaping practices could scalp most of the permeable A horizon from one position (leaving impermeable subsoil) and make the A horizon in other locations twice as thick. Such exposure will provide a surface zone with striking changes in infiltration, permeability, and erosion potential.

b) Water added to surface of these soils will infiltrate the A horizon (if kept vegetated so surface does not seal) and also move through the B horizon until it swells and becomes impermeable. Then a temporary perched water table will occur at the contact with the impermeable subsoil and subsurface flow will occur along this contact to lower-lying landscape positions. Thus, most of the flow will occur laterally once the soil is saturated to interceptor drains or to seepage points in the landscape where the B horizon is exposed due to natural erosion or scalping in a leveling operation. This phenomena is similar to subsurface flow at the contact with fragipans which is well documented at the OARDC-AEC plots.

c) Landscapes are not uniform with regard to erosion. Even in the soil survey areas where a slight degree of erosion is indicated, there will invariably be 10 to 20% of the area where erosion is of moderate degree, particularly on slopes of greater than 3 or 4%. This consid-

practice of deep plowing of the Mahoning-Ellsworth soils to improve water infiltration.

a) Micromorphology - These soils have masepic plasmic fabrics indicative of considerable history of swelling pressure phenomena upon rewetting. Such evidence suggests considerable pore pressure of water can develop and soil mass could swell to occupy voids and cracks opened by deep tillage.

b) Potential Linear Expansion (COLE)-Mahoning-Ellsworth soils have COLE values of the order of magnitude of 0.02 to 0.04 suggesting a potential linear expansion of 2 to 4% or 0.02 to 0.04 inch per inch of soil. Thus, for every 30 to 40 inches of soil, a lateral or vertical expansion of about 1 inch could be expected if there was no lateral stress (compression). This would essentially be the case if the soil was swelling into crack zones. Percent linear shrinkage for these soils range from 12 to 14% suggesting even greater potential volume changes than estimated by COLE. Thus, it is questionable if deep tillage would be very effective in Mahoning or similar soils. The subsoil materials would not remain open for a very long period.

c) It is considered highly undesirable to invert the calcareous C horizons of Mahoning-Ellsworth soils and place these materials at the soil surface. Such a practice would decrease infiltration and permeability of surficial horizons; it would also decrease the organic matter content of this zone and thus foster decreased aggregate stability. Establishment of a suitable seedbed would be more difficult if massive, compact C horizon materials were placed at the soil surface.

eration is pertinent to leveling operations, surface infiltration, and subsurface flow phenomena. Where soils are moderately eroded, the impermeable subsoil will be encountered immediately below the plow zone. To what extent a plow pan is developed at the base of the plow zone will depend on tillage history of plow depths. The permeability would be very restricted if a plow pan developed because non-capillary porosity in the plow pan would be nil.

d) In addition to previous considerations the depth to the impermeable subsoil of Mahoning-Ellsworth soils is conditioned by micro-environmental soil-forming conditions. At the contact with the impermeable subsoil, ped structural units have bleached silt coats indicative of reducing conditions caused by a seasonal perched watertable. The depth to the contact ranges from about 8 to 16 inches. Such a wavy contact may produce subsurface perched watertables on top of the impermeable B horizon which require several days to drain. Alternatively, if such a contact was sufficiently irregular, seepage zones could outcrop on steeper sloping landscapes.

All of the comments above express a real doubt that the soils selected (possible exception being the Chili) will be able to accept 60-90 inches of additional water over and above the normal precipitation. This failure could result in intermittent soil saturation and a marked reduction in renovation. For example, soil saturation results in poor aeration and reduction in plant growth and nutrient uptake. Reducing conditions also result in the greater mobility of heavy metals and changes in the rate of the microbial reactions so necessary for success of the "soil filter."

Crop selection and management

Land application plans for renovation of secondary effluent must consider the associated vegetation as an extremely important component of the total treatment system. Vegetation provides a significant mechanism for removing some nutrient elements from the soil, particularly N & P, markedly prolonging the period of time in which the soil will continue to function as an effective filter. In addition, good plant cover will improve the water infiltration properties of soil and increase evapo-transpiration rates, both highly significant to the concept of land renovation of wastes.

The Wastewater Management Studies for the Three Rivers Watershed have proposed soil management systems which are new and innovative, at least in the humid climate of Ohio, with only two major crops, corn and Reed Canarygrass being considered. The decision to use Reed Canarygrass extensively is probably a good one, since as noted earlier, the soils may be saturated periodically. Reed Canarygrass can withstand conditions of soil saturation very well and has the added advantage of being able to utilize high amounts of nitrogen, phosphorus, boron and sodium. However, caution must be exercised in proposing the establishment of large acreages of Reed Canarygrass for the Western basin treatment area. First, disruption of existing agricultural operations is a significant factor in rejection of the concept of land treatment of effluent in the Western basin. To a farm manager utilizing conventional methods of farming and raising corn, soybeans, and legume forages; the switch to Reed Canarygrass would be most difficult. It is also probably pertinent to point out that the data on pages 1-16, Wastewater Management Study, Phase III report comparing the quality of Alfalfa hay and Reed Canarygrass presents a distorted picture of the nutritional merits

of Reed Canarygrass. These data represent the quality of Reed Canarygrass under good management and alfalfa hay produced under poor management.

Second, the existing varieties of Reed Canarygrass are not as palatable as other forage grasses, are poor seed producers, and are difficult to establish. We also are not aware of what disease and insects might attack these varieties under conditions of intensive and extensive use. On the optomistic side, since limited attempts have been made to genetically improve Reed Canarygrass, we can assume that marked improvements could be made in the quality of Reed Canarygrass with a slightly greater research emphasis.

It is highly probable that the production of corn at even average yields will not be possible in any of the soil management systems proposed in these studies. Yield reduction because of soil saturation and reduced aeration would reduce the renovative efficiency of the corn for nitrogen and result in a deterioration of ground water quality. More will be said about nitrogen balances in the next section. It is also probable that most of our other agronomic crops will not yield well under the managements systems and effluent application rates proposed. Ladino clover and Timothy could possibly have some merit under certain conditions. This is an area which requires further investigation and field trials.

Speciality crops must also be considered for use in renovating at least part of the effluent of the Three Rivers Watershed particularly within the watersheds themselves. Extensive studies at Pennsylvania State University have shown that trees, either plantation or forest, do well when irrigated with secondary effluent. At Penn State, established forest sites were effectively used for irrigation during the winter months when effluent could

not effectively be applied to agronomic crops. The primary risk involved with effluent application to forested areas is the limited renovative ability of forests for nitrogen. Application rates of 1 inch of effluent per week for 20-30 weeks would seem feasible. Table 2 supplies data on the acres and distribution of forested areas in the Three Rivers Watershed. These areas present a potential for land application of secondary effluent produced in-basin.

The seven county area which makes up most of the Three Rivers Watershed is also a center for production of nursery stock. Data provided by the Department of Horticulture at Ohio State University shows that there are 440 Nurseries with 5163 acres of land in the Three Rivers Watershed. The normal irrigation requirement is about 2 inches of water per week. Although the acreage is not extensive the possible involvement of the nursery stock industry in utilizing effluent should be considered.

Another speciality area for consideration for effluent application is turf grasses, either those areas in parks, recreational areas, and golf courses, or sod producing industries. It has been estimated that there are 18,000 acres of golf courses in the Three Rivers Watershed, many which require extensive irrigation during the summer season. Parks and recreational areas, or areas set aside for "Greenbelts" are other alternative sites for effluent application. Turf grass sod farms, although seemingly an attractive industry for using effluent or sewage sludges, will not be significant because the market has been satisfied by the existing operators, and future expansion is limited.

Table 2. FOREST LAND AREAS IN COUNTIES COMPRISING THE ROCKY, CUYAHOGA, AND CHAGRIN RIVER BASINS1/

County	Forest Land Area				Nonforest Land Area	Total Land Area	Area In Watersheds4/	
	Noncom-2/ mercial	Commercial		Sampling error3/				
	1000 Acres	1000 Acres	Per cent	Per cent	1000 Acres	1000 Acres	1000 Acres	Per cent
Cuyahoga	---	41.7	14	32	250.1	291.8	224.5	77
Geauga	0.9	85.0	33	25	174.6	260.5	183.3	70
Lake	0.9	42.5	29	38	104.6	148.0	31.1	18
Lorain	1.7	43.2	14	31	271.8	316.7	19.3	6
Medina	---	47.4	17	28	224.4	271.8	118.3	43
Portage	12.8	82.2	26	20	221.6	316.6	154.4	49
Stark	---	42.0	11	29	326.3	368.3	7.5	2
Summit	---	58.8	22	26	203.9	262.7	167.4	64

1/ Adapted from: Kingsley, N. P. and Mayer, C. E. 1970. The timber resources of Ohio. U.S.D.A. Forest Service Resource Bull. NE-19.

2/ Productive forest land, but reserved from production of timber - (Parks, Watersheds).

3/ In percent for commercial forest land at 68 percent probability level.

4/ Areas measured from maps by dot-grid method and total acreage is about 3% high.

Renovative Characteristics of Soils for Effluent Components

Nitrogen: Nitrogen transformations of effluent nitrogen are highly significant for the success of the "soil filter" for effluent renovation. Failure to achieve the desired degree of nitrogen renovation would be recognized by an accumulation of nitrate nitrogen in tile lines and ground water supplies at levels above water quality standards. In essence the soil system would have failed to provide the desired degree of waste treatment. Excess nitrogen in groundwater or tile drainage represents a major potential problem to the success of land disposal of effluent and sludges. The following paragraphs evaluate the data and assumptions of the consultants with respect to nitrogen renovation (See Wastewater Management Study, Phase III Report, pp III-15 to III-18).

The consultant's decision to base effluent application on a proper nitrogen balance is basically sound. If the designed management and drainage systems are adequate to maintain an aerated root zone, then the quantity of nitrogen in excess of plant needs becomes the next limiting factor. It is extremely important that nitrate does not accumulate above that required by the vegetation, and leach into ground water supplies.

The assumption on nitrogen renovation as reported in the Wastewater Management Study Phase III report were over-simplified and not conceptually valid, e.g. no consideration was given to the nitrogen mineralized from soil organic matter, denitrification was estimated for the residual NO_3^- formed by nitrification of mineralized nitrogen during the growing season, the quantity of nitrogen associated with the non-harvestable portion of the crop was not considered, etc. For this reason the nitrogen balances were recalculated trying to improve the accuracy of the estimates (See Tables 3, 4 and 5).

Table 3. Nitrogen Balance in Soils (Cardington-Bennington Soils Cropped to Corn)

		Total	Mineral N Annually
a) Nitrogen in Effluent (16.4 mg/l @ 75"/year			
Organic N		26.8 lbs	18.8 lbs
NH_4^+ -N and NO_3^- -N		251.2 lbs	251.2 lbs
	Total	278.0 lbs	270.0 lbs
b) Nitrogen in Soil			
Soil Organic Nitrogen		2300 lbs	115 lbs
Nitrogen added with Precipitation		20 lbs	200 lbs
	Total	2320 lbs	135 lbs
c) Nitrogen Removed in Harvested Crop (160 bu of corn grain)			163 lbs
d) Nitrogen Associated with Unharvested Corn Residue (Stover & Roots)			150 lbs
e) Mineral Nitrogen Balance in Soil at End of Year (a + b) - (c + d) = 405-313 lbs			92 lbs
f) Estimated Loss of N by Denitrification (15% of 405 lbs of mineral N)			60.8 lbs
g) Residual N Subject to Leaching (e - f) = 92 - 60.8 lbs			31.2 lbs

For all subsequent calculations the effluent concentration of nitrogen will be considered that of the mixture of municipal/industrial wastewater and storm runoff and result in an effluent containing approximately 16.4 mg/l (See Phase II Report, Table V-1). No breakdown is given on the distribution of the nitrogen between organic, ammonium or nitrate nitrogen. For the purposes of these calculations the estimates of nitrogen distribution provided the CRREL Report will be used, i.e. 10% N is organic N, with the remaining 90% as mineral N equally divided between NO_3^- and NH_4^+. We will assume that all of the ammonium N will be nitrified during the growing season.

The assumptions associated with Nitrogen Balance calculations are as follows:

1) Organic nitrogen of secondary effluent is about 70% mineralized during first year.
2) Soil organic nitrogen is mineralized at the rate of 5% per year. The estimated organic nitrogen % = Soil O.M. x 0.05 = 2.3 x 0.05 = .115%.

The calculated nitrogen balance for the Cardington-Bennington and Chili soils cropped to corn in year are shown in Tables 3 and 4. The quantity of residual N subject to leaching in both instances is negligible and would maintain water quality standards. In subsequent years of continuous effluent application to corn, the annual amount of organic carbon added with the corn stover and roots will almost equal that mineralized from the native organic matter. At 5% mineralization and a soil organic carbon content in the Cardington-Bennington soils of 1.3% (organic matter 2.3%), this would equal about 1300 lbs of carbon or 2250 lbs of organic matter loss per year. Corn stover and roots would return 5000 lbs of residue carbon/acre, about 1500 lbs (or 30%) of which would remain in the soil after microbial decomposition.

Table 4. Nitrogen Balance in Soils (Chili Soils Cropped to Corn)

		Total		Mineral N Annually	
a) Nitrogen in Effluent (16.4 mg/l @ 60"/yr)					
Organic N		22.3	lbs	15.6	lbs
NH_4^+ -N and NO_3^--N		200.7	lbs	200.7	lbs
	Total	223.0	lbs	216.3	lbs
b) Nitrogen in Soil					
Soil Organic Nitrogen		2300	lbs	115.0	lbs
Nitrogen Added With Precipitation		20	lbs	20.0	lbs
	Total	2320	lbs	135	lbs
c) Nitrogen Removed in Harvested Crop (160 bu of corn grain)				163.0	lbs
d) Nitrogen Associated with Unharvested Corn Residues (Stover & Roots)				150.0	lbs
e) Mineral Nitrogen Balance in Soil at End of Year 1.					
(a + b) - (c + d) = 351-313				38	lbs
f) Estimated Loss of N by Denitrification					
(15% of 351 lbs of mineral N				52.7	lbs
g) Residual N Subject to Leaching					
e-f = 38 - 52.7				(--) 14.7	lbs

Table 5. Nitrogen Balance in Soils (Cardington-Bennington Soils Cropped to Reed Canarygrass)

		Total	Mineral N Annually
a) Nitrogen in Effluent (16.4 mg/l @ 75"/year)			
Organic N		26.8 lbs	18.8 lbs
NH_4^+-N and NO_3^--N		251.2 lbs	251.2 lbs
	Total	278.0 lbs	270.0 lbs
b) Nitrogen in Soil Organic Nitrogen		2300 lbs	115.0 lbs
Nitrogen Added with the Precipitation		20 lbs	20.0 lbs
	Total	2320 lbs	135.0 lbs
c) Nitrogen Removed in Harvested Crop (4 tons/acre at 3.1% N)			248 lbs
d) Nitrogen Associated with Roots, Rhizomes, and Stubble (3 tons @ 3.1% N) annually.			186 lbs
e) Mineral Nitrogen Balance in Soil at End of Year 1.			
(a + b) - (c + d) = 405 - 434			(--) 28 lbs
f) Estimated Loss of Mineral N by Denitrification (15% of 405 lbs of Mineral N =			60.8 lbs
g) Residual N Subject to Leaching			
e - f = -28 lbs - (+60.8 lbs) = -88.8 lbs			(--) 88.8 lbs

Since the carbon nitrogen ratio of corn residues is greater than 30:1 no net mineralization of the nitrogen will occur during decomposition and subsequent humification of these residues. At a C:N ratio of 10:1 for the organic matter formed during corn residue decomposition, the 1500 lbs of corn residue carbon converted into humic materials would contain 150 lbs of N.

The calculated nitrogen balance for the Cardington-Bennington soils cropped to Reed Canarygrass is shown in Table 6. A sizeable nitrogen deficit is shown for year 1. In subsequent years of a perennial grass such as Reed Canarygrass the annual amount of organic carbon returning to the soil as roots, rhizomes and stubble will exceed that mineralized from the native soil organic matter, e.g. as calculated previously about 1300 lbs of carbon or 2250 lbs of soil organic matter is lost annually. Reed Canarygrass might be expected to add 6000 lbs of organic matter as residue (roots, rhizomes and stubble) annually. This residue would contain 2400 lbs of carbon and 186 lbs of nitrogen (C:N ratio of about 13:1). Of this 2400 lbs of carbon, 25% is estimated to decompose the first year or 600 lbs of carbon leaving 1800 lbs of roots, resulting in a gain of 1800-1300 = 500 lbs of organic C or 862 lbs of O.M. per acre. Since the residual plant material has a favorable C:N ratio, net mineralization of 25% of 186 lbs of nitrogen should occur or 46.5 lbs of N. In subsequent years the mass of root and rhizomes will continue to increase to an equilibrium point where the 25% annual die back will just equal the annual addition. During this period of accumulation the quantity of mineralized nitrogen will also increase. Thus, the apparent nitrogen deficit in Reed Canarygrass renovation systems after one year will be reduced in subsequent years. Eventually we might propose a situation where the increased mineralization of root residues, rhizomes, and soil organic matter along with the effluent N would exceed the needs of the growing vegetation.

It is interesting to note that the conclusions drawn from these calculations and the consultants estimates are about the same, i.e., excess nitrogen from application 60'' or 75'' of secondary effluent to corn or 75'' of effluent to Reed Canarygrass results in the negligible accumulation of NO_3^- -N or an actual deficit. It is important to point out, however, that even the calculations in Tables 3, 4 and 5 are based on assumptions that may not be totally valid. Thus the assumed yield of 160 bu of corn on the Cardington-Bennington soils may be overly optimistic especially if the root zone is intermittently saturated. Furthermore, we do not know the level of biological denitrification which might occur, for so much depends on the availability of carbon as well as NO_3^- itself. Since the effluent contains little carbon, the necessary carbonaceous energy sources for microbial activity must be obtained from decomposing soil organic matter, plant residues, or root exudates. We also do not know the rate of nitrification in the rhizosphere of Reed Canarygrass. Ample literature (Clark and Paul, 1970) implies reduced nitrification in grasslands. Neither do we know the rate of nitrification in soils which could be intermittently saturated and partially anaerobic. What does seem apparent is that an estimate of 40% denitrification as used in the consultants report may be high and that further research is needed to improve our estimates. In the interim an estimate of 15% which is the average value found in the literature would be more acceptable (See extensive review of greenhouse and bysemeter studies, Allison, 1955).

Heavy Metals and Other Inorganic Ions: Nitrogen can be considered the short term environmental risk for land application of effluents (and sludges) while the accumulation of heavy metals must be considered the long term hazard. With a renewed interest in land recycling of effluents and sluges this concern has generated an extensive interest in the mobility and solubility of heavy metals in soils (Chaney, 1973; Leeper, 1972; Ellis and Knezek, 1972). These reviews as well as the rather good treatment of the problem in the Wastewater Management Study (See Phase I Report, Section X; and Phase III Report, Section III), make further detailed comments on heavy metal reactions in soils and plants unnecessary. The paragraphs which follow will be an attempt to expand on a few points which seem particularly significant.

The data presented in Table 6 is a compilation of the accumulation of heavy metals which might be expected with a 75 inch annual application of effluent and no prior at the source removal of metals from sewage (Alternative 5A). Time increments associated with this table are those used by the Associated Water and Air Resources Engineers,,Inc. (AWARE) for estimates of heavy metal loadings in sewage.

Total metal accumulation and percent increase in the soil (Table 6) are ways of focusing on the danger or potential hazard of heavy metals. These estimates put a number of nebulous concentration values into realistic terms for further evaluation. Such information is limited however, by not being able to show how the various metals are held in the soil (e.g. insoluble hydroxides, phosphates, sulfides; on the exchange sites; as organic matter complexes, etc.) These reactions will differ greatly and are dependent on soils and management. Note also that plant removal is a very ineffective

Table 6. Heavy Metal Applications for AWARE Alternative 5a* and Their Impact on the Soil Concentration of These Metals

Time Period	Metal	Sewage loading (lbs/day)	Disposal to land ** (lb/day)	Annual loading 75" effluent (lbs/acre)	Loading during period (lbs/acre)	Metal Removal by cropping Ø (lbs/acre)	Normal soil conc. ‡ (lbs/acre)	% increase during period
1980-1990	Ag	17.3	6.6	0.021	0.21	0.84	-	-
	Cu	1889	717.8	2.24	22.40	0.014	40(4-200)	56.0
	Cr	2798	1063.2	3.32	33.20	0.036	200(10-6000)	16.6
	Cd	70.3	26.7	0.08	0.80	0.18	0.1(0.02-14)	800.0
	Ni	1757	667.7	2.09	20.90	0.162	80(20-2000)	26.1
	Pb	4.03	1.5	0.005	0.05	1.02	20(4-400)	0.3
	Zn	2274	864.1	2.70	27.00	17.4	100(20-600)	27.0
	Fe	11575	4398.5	13.70	137.00		38000	0.4
1990-2020	Ag	20	7.6	0.023	0.69	-	-	-
	Cu	2303	875.1	2.73	81.90	2.52	40(4-200)	204.8
	Cr	3228	1226.6	3.81	114.30	0.04	200(10-6000)	57.2
	Cd	77.2	29.3	0.09	2.70	0.11	0.1(0.02-14)	2700.0
	Ni	2013	764.9	2.38	71.40	0.54	80(20-2000)	89.3
	Pb	4.16	1.6	0.005	0.15	0.49	20(4-400)	0.8
	Zn	2337	888.1	2.76	82.80	3.06	100(20-600)	82.8
	Fe	13541	5145.6	16.03	480.90	52.20	38000	1.3
2020-2040	Ag	19.7	7.5	0.023	0.46	-	-	-
	Cu	2385	906.3	2.83	56.60	1.68	40(4-200)	141.5
	Cr	3622	1376.4	4.29	85.80	0.028	200(10-6000)	42.9
	Cd	86.1	32.7	0.102	2.04	0.072	0.1(0.02-14)	2040.0
	Ni	2237	850.1	2.65	53.00	0.36	80(20-2000)	66.3
	Pb	5.81	2.2	0.006	0.12	0.32	20(4-400)	0.6
	Zn	2523	958.7	2.98	59.60	2.04	100(20-600)	59.6
	Fe	15435	5865.3	18.27	365.40	34.8	38000	1.0

* Heavy metal discharges by industry as estimated by AWARE into the municipal sewage collection systems of Bedford, Cleveland Easterly, Cleveland Southerly, Cleveland Westerly, Summit Twinsburg, and Willoughby.

** Estimated as 62% removal of all metals by secondary treatment.

Ø Removal by 6000 lbs of dry material e.g. 104 bu. corn or 3 tons of silage.
‡ Mean concentration and range of metals found in the soil plow layer. (Surface 6")

way of removing metals from the soil, i.e. the renovation efficiency of plants for metals is low.

From the data in Table 6 and from our knowledge of their reactions in soils we would not expect any serious toxicity or environmental problems from Pb, Cr, Ag and Fe. Lead should not be a problem because of its low rate of addition with the effluent and because it will be precipitated by the phosphate associated with the effluent. Chromium and silver both extremely insoluble precipitates in soil and should not be taken up by plants or readily leached within the soil. Although iron is added to the soil in considerable quantity, it should be rapidly fixed by precipitation and surface adsorption and is rarely toxic to plants.

The remaining elements considered in Table 6, Cu, Zn, Ni and Cd present the largest hazard associated with effluent applications. Zinc, copper and nickel are very toxic to plants and are present in relatively large concentrations in effluents (and sludges). As a general rule Cu is twice as toxic and Ni 8 to 10 times as toxic as Zn. Chumbley (1971) has introduced the Zn (equivalent) factor to take into account these differences among metals. He suggested that no more than 250 ppm Zn (equivalent) be added to agricultural soils with a pH maintained 6.5 in any 30 year period. If we use the data in Table 6 for 75 inches of effluent annually, we would exceed a value of 250 ppm Zn equivalent in 20 years, clearly a toxic level. However, it should be pointed out that Chumbley's "Zn factor" does not consider any of the other factors affecting metal toxicity except pH. Thus differences in soil texture, organic matter content, the presence of competing ions, the cropping system, and rate of reversion of the metals to extremely unavailable forms, are all processes which will affect heavy metal toxicity to plants.

Cadmium presents a different situation from that of Cu, Zn, and Ni. The absolute quantity added is not large in any year, or time period, (Table 5) although the percentage increase in the designated time period is large. Cadmium is of considerable concern, however, because it is readily taken up by plants and presents a health hazard to man. It can be expected that the FDA will eventually regulate the permissible level of Cd in foods to that of current natural background levels. To control Cd levels in foods we must be concerned with the relative uptake of Zn and Cd. Chaney (1973) has suggested that effluents and sludges reaching soil must have a Cd:Zn ratio less than 0.5% (1:200). With this ratio Zn toxicity will occur prior to the accumulation of Cd above permissible levels, and force the farmer to change management practices to correct the problem. The ratio of Cd:Zn in the effluent from the Three Rivers Watershed has a ratio of (1:33) or 3.0% and would present a potential problem. It is apparent from this discussion that Zn, Cu, Ni and Cd do present potential problems which could limit effluent applications to land. The decision of the U.S. Army Corps of Engineers to designate prior removal of heavy metals (AWARE, Alternative 3) prior to land application seems both necessary and commendable. It is also obvious that further research might alter our concern for the potential toxicity of heavy metals in soils. Judged from current interest, considerable research and clarification of this problem should be forthcoming in the next decade. Of particular concern is the process of "reversion" by which metals revert with time to chemical forms of lower mobility and plant availability. This process is presently very poorly understood but is apparently accelerated by a high pH (>6.5) and high concentrations of phosphorus in the soil, but slowed by increasing soil organic matter content, reduced soil pH and prolonged soil saturation. The

need for proper management of soils used for effluent renovation becomes obvious.

Some concern must also be given for the possible impact of foliar adsorption of heavy metals. Our knowledge in this area is also severely limited.

Other Inorganic Ions Present in Effluent

Phosphorous: The finer textured soils chosen by the consultants and any similar soils should provide adsorption of all phosphorus added with the effluent for the forseeable future and this should not limit effluent application rates. (See Land Treatment of Wastewater in Southeastern Michigan; U.S. Army Corps of Engineers, 1973). This would not be true if coarse textured sandy soils were chosen for effluent application. High yields of agronomic or specialty crops will extend this period because of the rather large quantities of phosphorus assimilated and removed annually.

Sodium, potassium, calcium and magnesium: The concentration of sodium, calcium, potassium and magnesium in secondary effluent will not be high enough to result in the accumulation of salts and an adverse effect on the growth of agricultural crops used in Ohio. When effluents are applied to soils, these ions will exchange with those on the soil exchange sites. Because sodium makes up a higher percentage of the cations in the effluent than on the soil exchange sits, more sodium will initially be adsorbed while calcium is displaced. If the soil horizons contain no free calcium carbonates (which is true for the solum of undistrubed Cardington-Bennington; Mahoning-Ellsworth, and Chili soils), the distribution of cations on the exchange complex will reach an equilibrium in 2 to 3 years at the 75 inch application rate. At this point the concentration of Na, Ca, Mg and K entering the drainage tile or ground water will be identical to that of the secondary effluent. Whether this becomes a serious condition will depend on the established water quality standards.

Boron and chloride: The high concentration of boron in secondary effluent is recognized in the Wastewater Management Study. Ellis and Knezek (1972) have reviewed the possible reactions of boron added to soil with secondary effluent. They have assumed that the soil solution of the furrow slice will be essentially at equilibrium with the effluent after the first year of irrigation. Since boron is found as the borate anion it will readily move downward into the tile lines or groundwater supplies and reach a concentration similar to that of the applied effluent. A secondary problem might arise if a slight increase in soil adsorbed boron would occur. The above authors have proposed that boron could approach toxic levels for growth of a semitolerant crop such as corn. With the possible exception of Reed Canarygrass, most plants will remove only about 1 or 2 percent of the boron which will reach the soil annually. We thus cannot expect plants to appreciably increase the renovation efficiency for boron. It seems apparent that boron may be a potentially serious problem associated with effluent renovation on land.

Chloride ion is not adsorbed by soils and will leach from the soil. Thus the concentration of chloride in the drainage waters will be similar to that of the effluent. Whether this is a problem will depend upon the initial effluent quality.

Other Factors Affecting the Success of Land Disposal

The consultant's reports did not address themselves specifically to the problems of disease and insect susceptibility of the vegetation growing at the land renovation sites. These problems could, however, provide limited restraints to the success of land disposal and periodically effect the operation of the soil filter, and the economic success of a land renovation area.

Either temperature or moisture can be decisive in the initiation, development or spread of plant pathogens. Certainly applications of 60-120 inches of effluent/acre/year will increase soil moisture and maintain a soil moisture tension of 0.1 bar or less almost continuously during the growing season (See previous discussion on problems in selections of soils). At the same time, these moist conditions will lower soil, air, and plant canopy temperatures. If both temperature and moisture are constantly favorable for a pathogen the disease will become serious. If only one item e.g. moisture is constantly favorable, the other factor becomes the limiting factor.

Susceptibility to disease may often be associated with vigor of the host. When a plant is grown under adverse conditions, e.g., water logged, poorly aerated conditions, the cell walls of the host root tissue will be less resistant to attack by a pathogen. The obvious increased incidence of root rotting fungi, damping off etc., in damp wet cold soils has been well documented (Yearbook of Agriculture, 1953).

For pathogens that affect the above ground parts of plants, environment is much more complex and variable than for the soil inhabiting microorganisms. Rain, dew, fog, and irrigation wet the surfaces of plants and supply moisture for the germination of fungal spores and multiplication of bacteria. Continually moist plant foliage or conditions of continually high humidity with the temperature conditions prevalent in Ohio can be expected to provide an environment which has the potential for severe disease problems.

Two other considerations influencing the hazard from disease pathogens will be noted briefly. If a pathogen is carried by an insect vector, environmental conditions affecting the vector will influence the severity

of infection. Second, large acreage of a single crop, e.g., corn or Reed Canarygrass grown under a rather uniform climatic regime, such as that under intensive irrigation of effluent, might provide a highly favorable environment for disease epidemics.

Insect damage and soil moisture might also be expected to be related. Wet soils usually result in an increased problem with most soil insects and with slugs. Seed corn maggot problems in corn are worse in wet soils, but could rather easily be avoided at the land disposal site by controlling effluent applications prior to planting.

There are other instances where adequate soil moisture apparently reduces economic injury by insects. For example, corn leaf aphids seldom cause economic loss where soil moisture is adequate. Potato leaf hopper damage is seldom evident in alfalfa when soil moisture is adequate.

Application of pesticides by irrigation: Control of pathogens, insects, slugs, and weeds on land disposal sites is one management practice of utmost importance for economic and functional success of this system of waste management. Conventional methods of pesticide application will have doubtful applicability where frequent irrigations wash chemical pesticides off of foliar surfaces or leach soil applied chemicals below the soil zone of maximum effectiveness.

With the proper choice of pesticide formulation, and technology, application of pesticides directly into the irrigation water would be an attractive alternative for pest control. The concept of applying herbicides and other pesticides through an irrigation system is not new (Mulliner, et al. 1972). Although there are many unanswered questions, there are several areas where this is now being done with aprinkler irrigation. Furrow irrigation does not readily offer a good means of transport and/or application

of pesticides because the movement of the pesticides through the soil would not be uniform; i.e., the soil would physically filter the insoluble compounds and there would be the possibility of the soluble materials becoming fixed on the soil particles before a uniform lateral distribution was obtained.

Pesticides that are to be applied to the soil could be metered into the sprinkler irrigation system. Pesticides vary in their solubility and in their required position on or in the soil. This would alter the amount of water which could be used in making an application. For example, if a material were used which was highly water soluble and was leached into the seed or root zone, crop injury would occur. Thus the amount of water would be critical and would probably be limited to no more than one to two inches at time of application. The exact reverse would be true of a material low in water solubility and where there was a good safety factor on the crop. In this case, provided the crop could tolerate the water, as much as 3 to 4 inches of water could be applied. Some pesticides must be incorporated or injected into the soil for effectiveness e.g. the thiocarbamates are highly volatile and must be incorporated. The common method is to apply these materials to the soil surface and till (disk or rotovate) the soil immediately, although sprinkler irrigation has been used to leach these materials into the soil.

For materials which must remain on the foliage of vegetation, the ideal method applies only enough water to wet thoroughly the foliage yet have a minimum amount of "drip-off." Any pesticide lost from "drip-off" would essentially be wasted and could conceivably injure the crop if it were susceptible to root uptake. Even on very dense vegetation, 200 to

300 gallons per acre of solution is considered enough to thoroughly wet the foliage. A possible alternative would be to apply the majority of the effluent and add the pesticide to the last small increment of effluent applied.

It is possible to have interaction of a pesticide with water quality. Hardness, pH and possibly the presence of heavy metals could cause problems.

Pilot studies need to be conducted before one could make firm recommendations on the use of pesticides in a program of water and waste disposal.

Sludge Disposal on Land

The Wastewater Management Study, Appendix 5 has addressed itself to the problem of sludge disposal on both agricultural land and stripmine spoils (See Phase I, pp 191-195; Phase II, pp 9-10; Phase III, pp II-13 to II-19). The general conceptual idea of recycling sludge nutrients and renovating marginal soils or stripmine spoils is excellent and one which should be encouraged. Unfortunately, we presently have limited information on which to base decisions on the proper rates of application to produce the desired plant growth response while not adversely affecting the soil or groundwater resources. The paragraphs which follow will critically evaluate the possible impacts of applying 10 tons/acre of sewage sludge annually or 30 tons/acre every third year to agricultural soils, or 100 to 200 tons/acre to stripmine spoils.

The short term limits to the amount of sewage sludge applied to agricultural soils will be the amount of available nitrogen and phosphorus added per acre. If we calculate an estimated nitrogen balance for both the 10 ton/acre and 30 ton/acre sludge additions, we derive the data in Tables

7 & 8. The 10 ton/acre additions seems to provide a reasonable nitrogen balance for the first year of addition. This would be particularly true if denitrification would be higher than the 15% loss used in this calculation, a possibility with the increase in available organic carbon associated with sludge additions. The value of 276 lbs of available mineral nitrogen for the 10 ton amendment is also in line with the suggestion of Aldrich (1973) that sludge amendments for corn be limited to a maximum of 250 lbs of ammonium nitrogen for the first year. Caution must be exercised, however, in projecting the advisability of continuing the practice of annual additions of 10 tons of sludge. The previous year(s) additions of organic nitrogen will be mineralized at a slow rate (~ 5% year) and contributing to the mineral nitrogen pool. This contribution would be substantial after about a 5 year period of consecutive sludge addition and would probably result in excessive movement of nitrate nitrogen into groundwater or tile drainage.

The situation with respect to excess nitrogen is considerably more serious under the proposed idea of applying 30 tons of sludge every third year (Table 8). The growing plant, corn or even Reed Canarygrass will not be able to utilize the mineralized nitrogen that will be available during the first year. This excess nitrogen will probably move into groundwater supplies or tile drain systems during the period prior to the second years crop. Thus in addition to the nitrate nitrogen becoming an environmental problem subsequent crops might have insufficient nitrogen without fertilization. It would seem that of the two systems proposed for sludge additions to agricultural soils, the one applying 10 tons annually would be most desirable. Application of more than 10 tons/acre annually would present a real danger to water quality. It is also worth pointing out at this time that other sludges, lagoon, aerobic digested, lime sludges etc. would be

Table 7. Nitrogen Balance in Sewage Sludge Amended Soils (10 tons annual application)

		Total N	Mineral N Annually
a) Nitrogen in sewage sludge (10 tons/acre) at 3% N			
Organic N		360 lbs	36 lbs
NH_4^+-N (40% of total N)		240 lbs	240 lbs
	Total	600 lbs	276 lbs
b) Nitrogen in Soil			
Soil Organic Nitrogen		2300 lbs	115 lbs
Nitrogen added with precipitation		20 lbs	20 lbs
	Total	2320 lbs	135 lbs
c) Nitrogen Removed in Harvested Crop (160 bu. of corn grain)			163 lbs
d) Nitrogen Associated with Unharvested Corn Residues (Stover and Roots)			150 lbs
e) Mineral Nitrogen Balance in Soil at End of Year 1			
(a + b) - (c + d) = 411-313			86 lbs
f) Estimated Loss of N by Denitrification (15% of 411 lbs of mineral N)			62 lbs
g) Residual N Subject to Leaching (e-f) = 86-62			24 lbs

Table 8. Nitrogen Balance in Sewage Sludge Amended Soils (30 tons annual application)

		Total N	Mineral N Annually
a) Nitrogen in sewage sludge (30 tons/acre) at 3% N			
Organic N		1080 lbs	108 lbs
NH_4^+- N (40% of total N)		720 lbs	720 lbs
	Total	1800 lbs	828 lbs
b) Nitrogen in soil			
Soil Organic Nitrogen		2300 lbs	115 lbs
Nitrogen added with precipitation		20 lbs	20 lbs
	Total	2320 lbs	135 lbs
c) Nitrogen Removed in Harvested Crop (160 bu. of corn grain)			163 lbs
d) Nitrogen Associated with Unharvested Corn Residues (Stover and Roots)			150 lbs
e) Mineral Nitrogen Balance in Soil at The End of Year 1			
(a + b) - (c+ d) = 963-313 =			650 lbs
f) Estimated Loss of N by Denitrification (15% of 963 lbs of mineral N)			148 lbs
g) Residual N Subject to Leaching			
(e-f) = 650-144			506 lbs

higher in both total and available nitrogen than would an anaerobically digested sludge.

Phosphorus in sludge is about equal to that of the ammonium nitrogen. Thus large additions of sludge will increase soil phosphorus considerably. Although the adsorptive capacity of the soil would be able to prevent phosphorus leaching for a considerable period of time, the available phosphorus will definitely increase with time. There has been some evidence that soybeans grown on sludge amended soils have suffered from phosphorus toxicity.

Heavy metal mobility and plant toxicity will represent the longer term limit to the amount of sludge which can be applied to land. The amount of metals in sludges is extremely variable, but represents a large percentage of that present in the sewage. Since heavy metal accumulation was discussed in a general way previously, little extra information will be provided at this time. Annual applications of sewage sludge to soils will eventually result in plant toxicity or the buildup of a particular element in the food chain. Until further research indicates to the contrary, the use of the zinc (equivalent) factor (Chumbley, 1971) or some other guide should be employed (Chaney, 1973).

Reclamation of stripmine spoil with sewage sludge is a procedure which has already shown considerable positive effects and even more potential. It is this writer's feeling that the adverse environmental impacts of presently unvegetated acidic spoils, moderates the concerns associated with sludge applications to agricultural soils discussed in the previous paragraphs. If appropriate political and economic restraints are removed, an immediate beginning should be made in stripmine reclamation.

Even with this optimistic viewpoint a few words of caution are provided. It is obvious that additions of 100 to 200 tons of dry sewage sludge per acre or spoil will provide an excess of nitrogen beyond that required by vegetation. Whether this excess nitrogen will become an environmental hazard must remain an open question. In the interim period it is hoped that additional research will provide data on which to base more precise estimates of rates of addition. It seems foolhardy to apply more that the amount of sludge which will produce the desired result and risk further damage to an already tenuous ecosystem.

Fish and Wildlife Considerations

The consideration of fish and wildlife as resources which might possibly be enhanced (or degraded) is essentially absent from any and all reports that have been reviewed. Aquatic life is expected to benefit from the pollution abatement resulting from enactment of any of the three plans proposed in Phase III of the Consultant Reports. However, attention has not been devoted specifically to designing fish and wildlife benefits into any of the plans although it would appear that substantial opportunity exists to do so.

Various reports indicate that there are potential benefits of significant proportion in the areas of stream (pollution abatement) and stripmine reclamation. Although the possibility of establishing fish communities in storage reservoirs and/or facultative lagoons is acknowledged, detailed consideration are absent. Possible effects on the wildlife communities of land treatment (irrigation) areas similarly have received no attention in the reports.

In our opinion, the failure to attempt quantification of the impact,

economically and/or sociologically, of land treated wastewater on fish and wildlife communities in the affected areas is a serious ommission of the reports which have been reviewed.

This is particularly true when it is recognized that as stated by the Wright-McLaughlin Engineers (1973, p. II-1). "The primary objective of wastewater management is to create social and ecological benefits by protecting the quality of receiving water bodies such as rivers, lakes, oceans and ground water systems" (italics ours). However, if social and ecological benefits are to accrue to the total biosphere, it is imperative that one environment not be degraded at the expense of improving another. Thus, if real social and ecological benefits are to be realized, terrestrial areas cannot be degraded in order to improve aquatic systems. The solution to avoiding terrestrial degradation has long been to introduce pollutants to water courses. The mere reversal of this process in order to improve water quality is not a solution to the 'environmental crisis'.

If wastewater is to be applied to land areas as a means of tertiary treatment and nutrient recycling, then it follows that social and ecological benefits must be realized in land treatment areas as well as receiving water courses. It is therefore important that these benefits are designed into land wastewater treatment plans if waste management objectives are to be met.

Watershed Management

The greatest potential for enhancement of wildlife (particularly fish) will probably occur when an entire watershed is under the jurisdiction of the agency responsible for wastewater management. This need not be the entire basin for one or more of the three major rivers in the study area, but might be for instance a 10,000 acre basin for one of the smaller

tributaries. Agricultural methods which minimize erosion and stream silt loads would be required within this smaller basin. Such management will almost surely result in stream water which is of much higher quality than those not under jurisdiction of the controlling agency.

The stream(s) in this smaller basin could quite possibly serve as sanctuaries for the more sensitive species of smaller fish, many of which appear to have been severely reduced in abundance or even extirpated by heavy silting and increased water temperatures. Re-introduction of some species to these areas may prove possible and desirable. Such high quality tributary streams may also serve as important spawning and nursery grounds for anadromous species that are able to 'run' the lower quality water of the main stream, but cannot reproduce successfully in it. Salmonids in particular can be 'imprinted' to return to a particular tributary be releasing fingerlings into it.

Enhancement of Aquatic Biota

There can be little doubt that the major disruptive forces on the ecology of Ohio waters have been pollution, silting and stripmine drainage (Trautman, 1957). Pollution in the Three Rivers Basin should be largely alleviated after tertiary treatment, as outlined in the consultant reports, has been installed. Significant opportunity also exists for ecological enhancement through correction of the problems of silt loading and (in other basins) stripmine drainage. These benefits should be specifically designed into the over-all plan.

Silt Reduction: Land treatment of wastewater will require some degree of administrative control over relatively extensive areas. As such, considerable emphasis could be placed on the implementation of no-tillage

farming practices in these areas in order to minimize erosion and stream silt loading. Some estimate of the favorable impact of no-tillage corn production on stream silting is given in Research and You (Ohio Agricultural Research and Development Center Bulletin 1061, 1972). Researchers measured 44,000 pounds of soil lost per acre from corn grown conventionally on a 10 percent slope <u>during a single heavy storm</u>. However, the same storm eroded only 62 pounds (about 0.14% of the former amount) per acre from no-tillage corn planted on a slope more than twice (21%) that of the conventionally tilled corn.

Significant fish and wildlife benefits would also accrue from the establishment of riparian forests for the stabilization of stream banks (Olson, Clark and O'Donnell, 1955). Stream temperature reductions resulting from the shading would also be of benefit.

Wastewater which percolates through the soil down to receiving streams should be of high quality. Summer low flows should be significantly increased, perhaps approximating historical flows that occurred during complete forestation. Streams flowing from watersheds which have major portions irrigated with wastewater managed as above will very likely be of much higher quality than has occurred in the last several decades. The possibility of re-establishing aquatic fauna in streams where they have been extirpated by low water quality seems great. Similarly, expansion of the desirable factions of the aquatic fauna which are currently at low population density because of marginal habitat conditions would be expected with improved stream quality.

<u>Stripmine Reclamation</u>: There are no stripmines within the Three Rivers Basin. However, the proposed use of sludge to reclaim areas outside of the

basin is well within the objective criteria of social and ecological benefit to the biosphere. Every effort should be made to combine the environmental 'loosers' of sewage sludge and strip pits into the ecological 'winner' of reclaimed and productive land.

Stream silt loading in stripmine areas is probably more severe than in agricultural regions, given similar ratios of watershed acreages largely devoid of plant cover. Reclamation of stripmines would be expected to significantly reduce silt loading, flooding, and the discharge of waters having a pH unsuitable for stream biota. Low flows should be improved. All of these factors should greatly enhance fish and wildlife populations in reclaimed areas, exclusive of the social and economic benefits to downstream water users.

Facultative Lagoons and Storage Reservoirs

Any benefits that might be predicted for the establishment of fish communities in the facultative lagoons or storage reservoirs proposed in consultant reports would be highly speculative. Although it seems likely that fish could be established at least in storage reservoirs, quite possibly in facultative lagoons also, coliform levels in these bodies of water, although admittedly an unknown factor also, will probably be too high to permit recreational use of the reservoirs.

It might prove possible that commercial and/or sport fish species can be reared in wastewater reservoirs (storage and lagoons), harvested and held alive in high quality water for a period of time to allow decontamination. Decontamination could be speeded up and/or enhanced by supplying them artificial foods containing antibiotics. They could then be sold (subject to meeting any required bacterial standards) or stocked into public waters.

Another possibility would be the culture of fingerling (small) fish. These could be stocked directly into public waters since they would generally be too small to enter the catch (either sport or commercial) for one or more years, thereby providing a suitable decontamination period. Artificially produced fingerling fish are normally harvested in the fall months. This would fit well with land treatment schedules. Storage reservoirs would be at their lowest levels at this time and facultative lagoons could be completely drained into them to permit the harvest of fingerlings (or large fish should this type of culture be decided upon).

Commercial fish culture for species tolerant of lagoon conditions currently does not exist in Ohio and estimates of the net returns from such a system in this area are of necessity speculative. Prices paid for channel catfish (*Ictalurus punctatus*) delivered alive to Ohio pay ponds by southern producers and/or commercial haul seiners from Lake Erie are in the neighborhood of $0.60 per pound live weight. An estimated annual yield of 250 pounds per acre from a stocking of 400 channel catfish fingerlings in facultative lagoons is probably not seriously in error, and may perhaps be an underestimate. The cost of fingerling catfish is variable, depending upon size and the number purchased. A cost of $100.00 per thousand in lots of 25,000 or more, delivered to the lagoon, is a reasonable estimate. This leaves a net of $110.00 per acre per year. Commercial operators will generally harvest and transport the fish alive for about $0.10 per pound, depending on the amount to be harvested and hauling distances involved. The need and cost of bacterial decontamination are unknown; however, $0.10 per pound would probably be sufficient. This leaves an estimated net return of $60.00/A/yr.

Markets for fingerling fish are currently near saturation. Therefore, any fingerlings produced would assumedly be stocked into public waters and their production justified on a social (recreational) basis rather than a cost reducing technique for wastewater disposal. Some idea of the value of fingerlings can be gained from current commercial prices (Table 11), assuming both a need for them in public waters and that the money required to purchase them is available.

It will doubtlessly not prove desirable for the wastewater management agency to undertake the expense of production and stocking fingerling fish. However, State agencies charged with this responsibility could be allowed to utilize the lagoons in order to greatly increase their fingerling production at a relatively nominal increase in production costs to them.

In summary, social and ecological benefits will be realized from pollution abatement in the water courses of the Three Rivers Watershed Management Basin. However, significant additional benefits should result from applying no-tillage agricultural practices to wastewater treatment land areas to reduce stream silting, establishing riparian forests to stabilize stream banks and lower water temperatures, reclaiming stripmined land to provide quality wildlife habitat and reduce stream silting and acid drainage, and utilizing wastewater treatment impoundments for the production of fish.

Table 9. Estimated annual productions and gross value per acre for several species of fingerling fish. Unitary prices as listed by Zetts Fish Hatcheries, Drifting, Pennsylvania 16834.

Species	Size (in)	No/A.	$/100	$/A
Largemouth bass	4	1,000	$ 75.00	$ 750.00
Smallmouth bass	5-6	300	200.00	600.00
Walleye	1-3	10,000	35.00	3,500.00
Crappie	1-3	20,000	20.00	4,000.00
Bluegill	1-3	30,000	12.00	3,600.00
Channel catfish	8-12	1,000	66.00	660.00

Economic and Social Considerations

Scope of Evaluation

The purpose of this section of the evaluation of the wastewater management study technical reports is to assess the proposed economic and social acceptance of varying degrees of land treatment of sewage from the metropolitan Cleveland-Akron area and other disposal alternatives

proposed by the study. This will be accomplished by assessing the potential economic and social impacts of land treatment and alternative disposal methods as primarily proposed in three plans contained in the reports by Wright-McLaughlin Engineers (1973) and the Buffalo District of U. S. Army Corps of Engineers in cooperation with the State of Ohio (1973, Ch. 7).

The scope of this evaluation includes some general comments about the economic and social dimensions of land treatment in general and specific to the plan proposed (primarily Plan C) by the Wastewater Management Study. Then the evaluation is centered on specific aspects of economic and social acceptance of land treatment in the proposed western basin and its interaction with the Three Rivers Watershed area in which the sewage is generated. The areas addressed are changes in farm practices, market development, land treatment without land purchase, and social and economic impacts on rural communities will be discussed. It will be apparent that the critique of the technical reports centers around Plans B and C as proposed. Plan B combines the advanced water-based treatment with land treatment within the Three Rivers Watershed area while Plan C extends the land treatment to the western land treatment area (Crawford, Huron, Richland, Seneca Counties). It is felt that an economic and social evaluation of the land treatment concept as expressed in those two plans is important in order to be able to evaluate sewage treatment policy in the future as each community and region is faced with such decisions now and in the immediate future. The weight of the evaluation will be upon acceptability of such a sewage treatment concept with little emphasis given to estimated costs of such engineering systems involved which seems adequate in the reports to date.

Overview on Economic and Social Dimensions

Few areas of public intervention have been discussed at length comparable

to the general area of water resource developments. Yet, in all that discussion, nothing as intriguing as a large scale sewage disposal plan with land treatment has entered the written volumes on water resource development until the recent proposals by the U. S. Army Corps of Engineers. Such a proposal holds promise for the conversion of an external effect with harmful attributes (nutrients discharged to the streams which weaken their natural assimilative capacities) to an external effect with potential beneficial effects (the same nutrients, nitrogen and phosphorus, applied to land for agricultural production). Though seemingly a totally beneficial and cost reducing method of sewage disposal the proposal is perplexing in terms of its acceptance; i.e., the perception of its benefits, and control by public intervention.

It is interesting that arising out of the lengthy discussions of water resource developments over the years the Council on Environmental Quality has suggested a framework from which to view the impacts of such investment plans and the wastewater management report suggests the same aspects of that framework as the goal of wastewater management. The Council has suggested a four-account system of evaluation reflecting the multiple objectives concept of project proposals. The accounts are 1) national economic development; 2) regional development; 3) social well-being; and 4) environmental quality. The Wright-McLaughlin Engineer report (1973, Page II-1) indicates "the primary objective of wastewater management is to create social and ecological benefits by protecting the quality of receiving water bodies such as rivers, lakes, oceans, and ground-water systems."

Crucial to the weight of each account in any evaluation is the measure or concept of benefits. Also crucial is the measure of total benefits

which involves benefits which accrue in one account at the expense of benefits which accrue in another account. Given an agreement on objectives benefits can be described as movement toward accomplishment of these objectives. Likewise, movements in the opposite direction are costs. Given this alignment, the objective function to evaluate public intervention in the process of solving community problems is rather simple. It is only when we introduce other issues which become objectives of equal weight that the evaluation criterion becomes complex. The effort to evaluate resource use becomes highly complex. Boating and fishing recreation become competitive in the use of the same resource, for example, and each demands a different water environment. We have to make descriptive assessments as well as economic and physical assessments to provide input into the political process which ultimately results in public intervention being applied.

We do not all agree on the proper distribution of income which leads to social well-being, but we can generally admit that there is a minimum level of social well-being for all citizens. We do not really know the dimensions or exact level of that minimum, however. Again, we are left with descriptive analysis.

Another issue of importance in the present evaluation is the regional impacts of transferring wastewater from a region of origination to a region of destination, as proposed by Plan C. The regionality issue (and thus the regional account) is really concerned with the interaction between the region or origin (Cleveland-Akron-Three Rivers Watershed) and the region of destination. These interactions change in degree, of course, depending on the particular plan proposed. Several plans for treatment have been proposed but three basic plans are finalized in the study to date.

The regional interaction involves the market forces which exert themselves. On the supply side of the market (region where wastewater originates) the ideal system may involve quite different motives for supply than the ideal system on the demand side of the market (the agricultural region which is the recipient of the treated effluent). This poses some implications for the interaction of the two regions. An equilibrium is attained in a market by the interaction of buyer and seller who are able to obtain mutual gains from trade. Mutual gains are possible if both buyer and seller bargain from similar positions of economic and political strength. If those strengths are unequal, then a countervailing power needs to be introduced in order for an equilibrium to occur.

The case we have in the Three Rivers Wastewater Treatment proposal before us is a case where the seller (region of supply) has a commodity which must be disposed of and the buyer (agricultural region of demand) has a potential demand for that commodity. The wastewater must be treated and the nutrients (nitrogen and phosphorus) disposed of. Agriculture has potential demand for such nutrients in the production process. The regional interaction would proceed on this basis should Plan C be initiated. One crucial point that should be realized is that mutual gain in such a trade of nutrients from one region to another implies the purchase of such nutrients on terms satisfactory to the buyer. Only then is demand expressed. The same issue exists with respect to the water which is transported from the region of origin to the region of destination.

We also have the problem of sellers of use rights versus demand for use rights for disposal of the effluent. In this case, the region of supply becomes the western land treatment area and the region of demand becomes the Three Rivers Watershed area. This problem will be discussed

further below but the same complexities of exchange alluded to above exist as will be explained.

As this evaluation proceeds, it is important that these issues discussed above be kept in focus. Many of the details presented in the evaluation refer back to the arguments laid out above. In discussing the land treatment concept of Plan C, continual reference will be made to regional interaction and benefits and costs of such interaction without directly measuring such.

Changes in Farm Practices

In what follows in a discussion of farm practices and the impacts of land treatment of wastewaters on such practices, Plans B and C as proposed will primarily be the focus of the critique. It is important to give some background on existing farm practices and the practices which are compatible with land treatment of treated effluent originating from a metropolitan area such as the Cleveland-Akron area.

North Central Ohio (the area of proposed land treatment in Plan C) is characterized by generally a pattern of extensive agriculture primarily devoted to the production of cash grains and feeder livestock. Specialty crops are also being produced in North Central and Northwestern Ohio such as sugar beets, tomatoes, cabbage, and pickles which are grown on suitable land in Seneca and Sandusky counties. These crops are also concentrated to some degree in Wood and Putnum counties further west of the proposed land treatment area.

Considerable investment has been made by farmers and the rural communities of this area in support of this intensive agricultural enterprise. The infrastructure of the rural communities is centered around servicing

the cash grain, feeder stock, and specialty crop operations of the area. Given this investment pattern and the present situation of government policy in the agricultural sector; i.e., price supports, acreage bases depending on historical acreage planted, and market certificates, for commodities such as corn, soybeans, wheat, and sugar beets, agriculture production should become even more intensive.

Land treatment, although a viable alternative for the treatment of municipal sewage, is best suited to the less intensive grassland-beef agricultural production complex or to nursery stock or woodlands enterprises. Economic research on future farm production patterns for Ohio indicates that Eastern, and particularly Southeastern Ohio, are the areas in the state having potential for the expansion of the cow-calf and forage consuming activities. Western Ohio remains the area for Winter feed expansion since Winter feed in that area is cheap. This is also the area where feedlot expansion should come in the future, though some additional feeding operation expansion could occur in the proposed land treatment area.

The force behind changes in existing cropping patterns in North Central Ohio is not the nutrients or the drainage that would be forthcoming in such a large scale land treatment system as proposed in Plan C but the water that is involved. Land treatment is a viable method of sewage disposal in that nutrients (nitrogen and phosphorus) are converted from public nuisance by-products of the consuming activities of society to a beneficial use in agriculture. The problem that exists is the water that would be applied to land in an area where irrigation is only required in minute supplemental amounts for the existing agriculture in North Central Ohio. In arid areas of the country the method looks like it would be an acceptable treatment alternative and the water would be desired. With such application of water

proposed in Plan C the existing enterprises would have to convert to a more compatible enterprise with such treatment.

The conversion of the existing enterprises is not economically acceptable by farmers because incremental losses in income will result as one converts from the highly intensive agriculture to the extensive agriculture. Such losses would have to be compensated. Artificially high prices for beef or pork would have to be paid in order to induce a shift from the present enterprises to the compatible beef-grassland enterprise in the land treatment area. If those prices are not received then high fees for use rights will have to be paid in order to induce farmers to convert from intensive operations to extensive agricultural operations and into the business of supplying use rights to a metropolitan authority which desires to dispose of its sewage. More will be explained about the use right mechanism in a later section.

Beef or pork production in the North Central Ohio has to compete with high value crops such as sugar beets, tomatoes, pickles, and vegetable crops as well as cash grain crops grown in the area are produced under government allotment and support price programs. The expansion of nursery crops grown on land irrigated with the treated effluent is a possibility, but again, the expansion is not probable on land in Seneca, Sandusky, Richland, and Huron counties. The expansion of production of nursery crops is more likely to occur in the areas where it exists. That area is within the Three Rivers Watershed primarily in Lake County.

This points to the fact that although some changes in farm practices would have to occur if Plan B (land treatment in the Three Rivers Watershed) were to be followed, the conversion would be less disruptive since agri-

cultural enterprises which are compatible with land treatment already exist within the basin. Considerable amounts of dairy production, nursery and ornamental, woodland, and grassland enterprises exist within the Three Rivers Watershed.

To conclude this section we express skepticism in the possibility of changing farming practices in the North Central Ohio area from the present intensive agricultural production patterns to be compatible with the land treatment process. We are less than optimistic that benefits will accrue in the region proposed as recipient of the treated effluent. It is imperative that agencies proposing such viable engineering and physical schemes as land treatment recognize that it will not do to hypothesize increases in crop yields as measures of benefits of the system when such yields are in crops such as grass while current crops consist of high valued crops.

Market Developments

It is important to point out that we cannot calculate or infer benefits from increased crop yield as a result of nutrients and water (if yield increases will occur with the added water) being applied to land unless there is a recognized market outlet (demand) for such increases. Farmers in the proposed land treatment sites do not operate in a vacuum. Increased yields or increases in the output from any newly introduced enterprise must have a market.

One other important thing to recognize is the working forces of the market; i.e., the interaction of demand and supply in response to price and quantity changes. Increased production will likely depress prices within the region and to a lessor extent nationally because of farm support programs. However slight such depressions may be, they cannot be assumed away in the evaluation of public investments because of their income redistribution effects.

Ohio is a beef importing state and it is true that meat packers in Sandusky, for example, receive considerable numbers of slaughter cattle and hogs from neighboring states. Given the trend in income increases in the nation and Ohio, the potential for the expansion of the beef market exists, particularly in the urban areas of Cleveland, Akron, and Toledo. The production to meet such a demand will likely increase in Southeastern and Western Ohio (Shaudys and Sitterley, 1973).

With respect to increases in nursery crops production by introduction of such crops in Seneca, Richland, Crawford, and Huron counties, the present market would not be able to absorb such increases without decreases in prices. This type of enterprise becomes more intensified nearer the urban centers. Increases in production is likely to occur in those areas in response to increases in new housing developments and increases in income in the urban centers.

Christmas tree markets could probably absorb approximately 500 to 1,000 additional acres per year being devoted to production before prices would be depressed. Given the long maturing cycle of Christmas trees, trees planted at the present would be harvested six to seven years from now. At an expansion rate of 1,000 new acres devoted to new production each year today's trees would be coming onto the market when an additional six to seven thousand acres are in production. This market can expand some, however the acute problem of seasonality in demand makes the production decision highly complex. The price of harvested Christmas trees can rapidly decline to zero because of the seasonal nature of demand even though the product has not deteriorated.

Agricultural products are generally inelastic in demand; i.e., with a one percentage increase in price the quantity demanded will decrease less

than one percent. However, that means that with changes in quantities offered on the market, prices will fluctuate more than the given changes in the quantity offered. So there is a tendency for price depression when additional quantities of farm products are supplied to the markets as a result of the increased production from such projects as water development and irrigation as exists in this case.

Land Treatment without Land Acquisition

The estimated land cost of Plan C; i.e., the total land treatment plan, is considerably higher than the estimated land costs for Plan B (combined land and advanced biological and physical chemical treatment). The land costs of the former plan are approximately $93 million, whereas the costs of the latter are approximately $11 million (U. S. Army Corps of Engineers, 1973, page 158). These estimated land costs for both plans include land purchase for the storage and aereated lagoons as well as the vast amount of acreage needed in order to treat the secondary effluent by the land filter method.

It is important to emphasize that land acquisition is another reason which makes the land treatment alternative unacceptable for the region proposed to receive the treated effluent; i.e., North Central Ohio. Such large tracts of land would be exempt from property taxation, the major source of revenue for the existence of the rural counties and communities involved in the area, at least the major source of financing community services. With the decline of rural communities present at this time, such a tax loss could hardly be viewed as a benefit by the land treatment area, particularly North Central Ohio where the tax loss would be felt most. Tax loss would also occur if land is purchased within the Three Rivers

Watershed. Though the burden of the tax loss would be less than for the Western basin counties, such a tax loss cannot be assumed away as negligible unless another form of revenue takes its place.

The technical reports of the U.S. Army Corps of Engineers, 1973, and Wright-McLaughlin Engineers, 1973, indicate that Plan C is the cost effective plan in achieving the goal of treating the sewage from the Three Rivers Watershed and discharging water to Lake Erie tributaries free of nutrients. The plan is cost effective even when land acquisition is assumed. However, the cost effectiveness tool to evaluate public investments merely costs various plans to achieve the same objective. Losses, or second round costs as a result of the plan are not included in the cost effectiveness calculus and are thus not included in any of the plans under evaluation. The benefits and costs associated with development versus preservation are not included. This criticism can also be directed to current methods of evaluation using the benefit-cost calculus. It is important to point out that tax losses, enterprise change losses, inflated or deflated land values as a result of the treatment plan and associated land acquisition are not considered.[1]

Regional Interaction: Before discussing an alternative to land acquisition included in a land treatment method such as proposed by Plan C, or even Plan B, it is important that we understand the interaction of the two regions involved and the perception of what is involved economically

[1]Recent survey of land sales in Sandusky, Seneca, and Huron counties indicate that land intensely cropped in these areas is worth approximately $800/acre. This is a higher land value than that which is considered in the technical reports. cf. worksheets of T. F. Glover (1972).

in land treatment and the transportation of water from one region to another. This will help us assess the acceptability of land treatment by cooperation or land use right.

The regional interaction involves two regions with different motives and bargaining strengths. As a result, problems of control and acceptance of Plan C would likely arise if implemented. For Plan B, the problem of control still exists, but the plan has internalized the acceptance problem; i.e., the region of sewage generation is also the region of sewage destination. The problem is perceived as how to handle the treatment of one's own unfortunate by-product.

For Plan C, the supply region (Three Rivers Watershed) has basically different reasons for the operation of land treatment and control of such a treatment system than does the recipient region. It is true that the Western basin could use the nutrients and the drainage. This would lower the costs of production. However, the nutrients are needed at certain times in order to be effective inputs into the agricultural production process. The problem that the western basin is confronted with is the additional water as alluded to earlier. Some supplemental water is needed only for short periods of time and the application system needs to be very flexible.

The region of supply is seeking a system whereby a constant treatment process is ongoing because sewage generation is a continual process as a by-product of consumption and production activities within the region. The supply region needs a certain degree of control over the constant operation of the treatment process. The best method of control of land treatment at present seems to be by control of the land and its use.

The objectives of the two regions are not compatible. Therefore, a means of public intervention is sought in order that such a system be

operated in a feasible manner as perceived by the two parties (regions) involved. This is usually accomplished through the political process. However, there will be losers and gainers resulting from such a process. New policy should be undertaken after careful assessment of the losses and gains and the reasons behind such has been achieved.

Perception: There is a crucial issue involved in the perception of the land treatment alternative that should be understood by public agencies directing community service delivery such as sewage treatment by the powers granted government. This issue concerns the role of risk, uncertainty, and irreversibilities. The perception of land treatment is highly related to the roles these concepts play. Economists attach specific definitions to these three terms and they are important in this evaluation. A risky situation is one to which probabilities can be attached. One is gambling when he engages in risky activities. Uncertainty is reserved for those situations to which no known or stable probabilities can be attached. Irreversibilities has special meaning in our present evaluation. Natural resources, the objects with which we are dealing with in land treatment, are not produced as are most other goods and services with which we are acquainted and some are not readily duplicated. If destroyed or exhausted, an irreversible situation is created. We may not know the probability of such an event occurring, i.e., we are operating in complete uncertainty. The assessment of value of the natural resources becomes much more complex than such assessment of produced goods. Concern over the environment is based upon the notions of uncertainty and irreversibilities.

The ethic which argues for construction with monitoring to follow must be viewed with apprehension given the definitions of uncertainty and irreversibilities. Monitoring is the process of transforming uncertain

situations into risky situations, i.e. we can attach probabilities to the occurrence of events by experience with their occurrence. The risk statement (statement of probability of an event) is valuable information for the decision process before a project is implemented, but post-project monitoring will do little to correct an irreversibility such as an ecological, and hence, an economic alteration. Implementation of such a large scale system given the uncertainties of the economic and the social impacts is viewed with skepticism before uncertainties may be transformed to risk statements on a smaller and less disruptive scale where irreversible alterations can be minimized or the probability of their occurrence can be made known.

The recipients of the sewage will and do perceive many uncertainties attached to such a plan for sewage treatment as proposed in Plans B and C. Some of the physical, biological, and engineering uncertainties can be transformed to risk statements as the technology of land treatment is made known to persons involved as recipients. Even some of the economic and social uncertainties can be transformed to risk statements. However, many uncertainties exist particularly in a proposal the scale of Plan C. This will have bearing on cooperation in land treatment and the supply of land use rights by the recipient region to the sewer authority as will be seen later.

Use Rights Versus Tax Mechanisms for Land Treatment and Acceptability: If land is not to be purchased for the land treatment process, then the institution involved, sewer district, conservancy district, "super river basin authority," etc. will have to enter into some agreement with farmers separately or in concert to use the land for irrigation of treated effluent or be granted powers to use the land and compensate for such use. This will involve a lease or special irrigation-drainage easement. Through such instrument the ownership and use rights of the land involved will be altered and separated in order to affect the control of such a system of sewage treatment.

Will such an instrument be acceptable and render the land treatment plans feasible in terms of cost? The substance of that question and partial answer is what is treated in what follows. Keep in mind the earlier discussions on regional interaction, perception, and the meaning of a change in farming practices involved in the western basin.

Let us briefly touch an economic concept which illustrates the acceptance of Plan C primarily and Plan B to some extent. This is the concept of externality. Externalities are external forces generated by the consuming or production activities of one economic agent which affect the consuming and producing activities of another economic agent. These are sometimes called spillover effects and this is particularly an appropriate term and is related to sewage generation. Externalities can be both harmful (an imposed cost) and beneficial (result in a benefit). In Plan C the external effect (nutrients which deteriorate the assimilative capacity of streams) is to be transferred from those affected in the use of Lake Erie and its tributaries in the Three Rivers Watershed to another set of economic agents in the Western basin in hopes that the externality may be modified and be turned from a harmful spillover to a beneficial effect on agricultural production. Those hopes can be realized and such a proces is the reason that land treatment is a viable means of sewage treatment physically and biologically.

The subtle point to be considered here deals with the conversion of one pollutant (nutrients) to beneficial use but in the process of conversion another external effect is introduced and is justly perceived as imposing a cost on the recipients of that substance. Because of the amounts of water involved in the land treatment process as proposed by Plan C, the water becomes a harmful spillover (imposes a cost). In order for the land treat-

ment process to be successful at water application rates proposed by Plan C, existing agricultural enterprises will have to change from intensive agriculture to extensive and lower valued agriculture as discussed earlier. What needs to be recognized is that this imposes losses as the conversion takes place.

Once the irrigation application rate is at a certain point to force the conversion, the incremental decline in profits of such conversion will likely decrease as the point of complete conversion is approached for an area. At this point farmers cease the intensive production activity and engage in a next best alternative. Actually, farmers cease the corn-soybean-specialty crop production activity and desire to engage in the business of selling (supplying) externality rights (use rights to irrigate effluent) which would be a more profitable alternative. Furthermore, at any positive price for use rights, the farmer would desire to supply use rights beyond the amount needed for the unique irrigation application rate which technically forces the conversion in production and loss in profits from the present enterprise. The farmer would make greater total profits from such an action and accepting an infinite amount of externality if he could do so.

The demand for such rights would be finite depending on the price of the use right set by fiat or artificial market (as determined the costs of alternative sewage disposal methods). The result is that no equilibrium occurs. There is no basis for regional interaction on an equal bargaining basis.

The point of this discussion is that if the price of the use right is high enough farmers will turn their fields into strictly sewage filter fields and manage farming operations in accordance with ideal land treatment

conditions. All this assumes we believe in our common law upbringings and the recipients of harmful externalities be given the control over property rights.

The difficulty of working out a use right mechanism can be understood intuitively in a different way. The farmer, holding the rights, would have to be offered a positive price to accept the treated effluent (water mainly). The increased water can damage him by at most his total profits in the existing intensive production activity (in terms of an economic risk statement). Thus, if he can sell enough use rights (rights to use his land for nutrient filter via the hydrologic and soil vehicle) and change his current production mode, he can always improve his profit position.

The process of payment for a use right is an artificial market mechanism. However, the instability of the market in this case signals that an efficient allocation of resources may require farmers to cease current operations. We conclude that if the water is perceived as substance imposing costs and uncertainties exist, the artificial market mechanism (lease, easement, use right) will not work in this case. Furthermore, a conversation district mechanism of cooperation will not work because an external effect which imposes a cost exists. The mechanism only works if strict cost reductions are perceivable by farmers involved and they can remain in production activities which bring high returns.

<u>Operation Via a Tax Mechanism</u>: Can we then expect a tax mechanism to lead to an equilibrium? If a metropolitan sewer district is set up to include the total area (the two regions) involved in land treatment (and it would have to be so structured), the authority tells the farmers what application rate will apply. The farmer's incremental losses will be known

by him if he has to divert some production from existing enterprises. A tax, based on that amount of loss, imposed on the Cleveland-Akron region would have to be equal to the price the region would have to pay to dispose of the announced amount of effluent. However, if that application rate is high enough to force total conversion to forage production, then marginal losses in the intensive production are zero and the tax price is zero. The Cleveland-Akron region would desire to dispose of that amount of effluent which would be disposed assuming zero payments for use rights.

Should the farmer operate or not? The answer to that question depends on whether society is a net gainer or loser from having the farmer engaged in his present enterprise at the proposed land treatment location. A detailed analysis of the incremental profits and losses of farmers in the land treatment location, and the gain of cost reductions in sewage treatment, would have to be undertaken in order to provide adequate information to answer such a question. We can point to some direction concerning this question, however. If the soil in the particular treatment location is rich so that considerable differential rent on such land can be obtained, and if intensification of sewage disposal within the sewage generating region means gains due to disposal cost reductions, then the farmer should continue his present operations and mode of production.

We have reason to suspect such is the case. Considerable differential rent can be obtained for land in North Central Ohio on which corn, sugar beets, tomatoes, and other specialty crops are produced.[1] Economies can be obtained in intensification of conventional or land treatment sewage disposal within the region of sewage generation.

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[1]Data collected in Seneca and Huron Counties indicate net rent can run as high as $38-42/acre (Glover, 1972).

We conclude that, if the tax mechanism is set up by granting such authority to a super (multiregion) metropolitan sewer district, there can be no assurance that a preferred equilibrium (acceptance by farmers and the Cleveland-Akron region) will be found. In fact, more than one equilibrium would likely occur; i.e., multiple tax prices -- effluent application rate levels exist which are equal contenders for the preferences of all parties involved. The only sure way to find the most preferred point would be to engage in the kind of macro benefit-cost analysis alluded to above. This is an extremely complicated task and merits research if for nothing else than to delineate shortcuts in such a procedure.

Land Treatment Perception and Imperfect Markets: If the land treatment process as proposed in Plan C is viewed with uncertainty or even viewed as a public nuisance by the area involved then the sellers of rights (use rights to irrigate the treated effluent) react to each other on the supply of rights side of the market. Use rights supplied by one land holder must be supplied by all involved in the designated treatment area. A traditional competitive market where use rights prices are taken as given cannot exist. The appropriate efficiency condition for the production of the public type good (the effluent) is for the region of origination to be paying a price per unit of externality (water application above a certain level which causes a transfer from existing enterprises to lower valued enterprises) equal to the sum of all marginal losses of recipients of the externality. The simplest way to reach that point may be to set up a market between a sewer district and each recipient of treated effluent. Quantity of effluent would be varied simultaneously on every market and each recipient would be asked to announce his going price; i.e., his marginal

losses with each increment of change in effluent application. Obviously, this type of scheme would require a substantial amount of centralized administration.

Now, if the use right suppliers (the effluent recipients) do not act in the market as though price of use rights is given, then a complex situation results. Given our common law concept of who should have rights, the recipients will use their rights as power to block any production of the externality, if treated effluent is viewed as a potential harmful external effect they would be receiving. The sewage generating system will only be permitted to transport to the land treatment area that amount of effluent for which use rights are obtained from sellers of those rights. Individual sewer district - use right seller negotiations will result.

In such case, each seller of rights will be responsible for but a small portion of the total price the sewer district must pay for increasing the application of the effluent to the land for filtering nutrients. The seller of the rights will have little effect on the total amount of use rights the sewer district demands. Thus an incentive to the seller is created to sell use rights at an extortionary price well above marginal losses, or at a positive price even if losses are negligible or zero. The outcome of such a case is that less than the desired amount of use rights will be sold and the use right price will be driven up to the land acquisition price, thus rendering the land treatment alternative infeasible because of cost considerations.

There is another outcome worth discussion. This case involves some degree of coordination of the recipients of the effluent in the land treat-

ment area. If the recipients acted in complete concert, they would act as a monopolist and sell use rights in an amount which equates marginal revenue and marginal cost for the group together as a single monopolist. The outcome results in more use rights being sold than in the case of individual negotiations with the sewer district and each recipient. However, the amount of use rights sold depends on the degree of coordination of use rights suppliers. Again, losses may be overstated by the recipients acting in concert and the price of use rights would be higher than the sum of marginal losses.

This discussion thus far points to a principle problem that exists in the land treatment process in which the treated effluent is transported from the region of origination to some other region of destination. Because of the negotiations that could occur which involve uncertainties about the process and the excess water, the cost of such a treatment process may no longer be cost effective as indicated by the costs estimated for the Plan C proposal. Plan B, though involving many of the same problems, may be the best alternative, achieving a compromise in cost, but still achieving the least cost treatment by areated lagoon and disposal on land within the Three Rivers basin which generates the sewage.

Water Quality Agencies to Implement Land Treatment

With the preceding analysis in mind we can now briefly outline the types of authorities or agencies that could be used to implement land treatment and evaluate their effectiveness.

Conservation District: The conservation district concept has been successful because a benefit (lowering production costs) has been obtained by farmers. Through the program, public funds have been channeled to

farmers to lower their production costs via land improvement. The program is acceptable only if farmers are allowed to produce those products from which greatest return is forthcoming. These enterprises have been those supported by government price policy and the beef production enterprises in the Western U. S.

Thus there have been incentives to comply with conservation programs because they have enabled farmers to respond to price policy, lower their costs of production, and improved the productivity of land. It is true that drainage and nutrients forthcoming from land treatment will lower farmers costs and improve the productivity of the land in North Central Ohio. However, uncertainties and risk still remain with respect to the water application to the land which would be involved, particularly as proposed by Plan C. As a result, the conservation district concept becomes a weak instrument through which to implement and control sewage disposal via land treatment.

Conservancy District: The powers of a conservancy district in Ohio have been rather restrictive in terms of policing powers compared to the taxing powers. They have to levy special construction assessments. The taxing mechanism has been used primarily for construction of flood control structures within a particular watershed in Ohio. In order to control the functions of flood control the district usually has had to purchase land contiguous to flood control structures. Otherwise, control of land use would be difficult because of the weak policing powers delegated such districts. Such would be the case for sewage transport, treatment, and land disposal. The boundaries, powers, and purposes of a conservancy district would have to be expanded considerably to implement Plan C as opposed to Plans A or B.

Metropolitan or Regional Sewer District: Sewer district control of the irrigation system is needed in order to completely accomplish the goal of the region of effluent supply; i.e., treatment, disposal, and removal of nutrients from the effluent in compliance with recent legislation.

In order to have control without land acquisition the sewer district would have to possess a great amount of policing powers granted by the state. Otherwise the land use would not be controlled nor could the flow of effluent. Such a district would become a "super river basin" authority, having jurisdiction over several river basins and the management of water quality for those basins.

However, in order to initiate action for such an authority some basis for negotiation needs to be in existence. From our previous discussion, the regional interaction involved is on an unequal basis. Such a district authority would be complex in its set-up and may not be forthcoming unless property rights are realigned. This would mean a major institutional change which would not be easy to come by. Again, such a district would be easier to set up to administer Plans A or B, or a separate western basin sewage authority.

At this point we suggest some criteria for regional water quality management such as that involved in the land treatment proposals of Plans B and C, or for Plan A in the case of advanced biological and physical chemical treatment. Here, we rely entirely on previous research (Kneese and Bower, 1968, Ch. 14).

1. The regional authority should internalize the major externalities associated with wastewater generated in the region.

2. The regional authority should have the power to implement the control necessary to improve water quality.

3. Water quality and other aspects of water resource development and use should be integrated in the actions of the regional authority.

4. Water quality and land use should be integrated in the actions of the regional authority by a mutual basis for managing such land use as it relates to improving water quality.

5. Water quality improvement should be integrated with other aspects of environmental quality.

6. The regional authority should be set up by all affected parties and should provide an opportunity for affected parties to have voice in decisions.

It is obvious that some of these criteria are not mutually compatible in the land treatment concept proposed by Plan C. It is also obvious that the sewer district concept has to expand to a total environmental district concept and other districts would have to be integrated into its function and authority. Such an authority as an environmental district would have to be a creature of state law. Both the financing and authority would come primarily from the state who should assume the major responsibility for environmental quality control as a vital activity in exercise of government powers.

Social Impact on Rural Communities

In this section we attempt to evaluate the land treatment alternative in terms of its social impacts on the rural communities involved in the land treatment area. Again, by attempting such an evaluation we address ourselves to land treatment as primarily proposed in Plan C, and particularly the problems of land acquisition as that seems to be the viable alternative in terms of system control but presents serious social problems.

The Social Impact of Land Acquisition: The impacts of land acquisition

on the social structure of rural communities are evaluated by drawing from some research on land acquisition and forced relocation in other water resource development areas (T. L. Napier, 1973, and Napier and Wright, 1972).

The American people have basically accepted the position that provision of water sources has priority even over discomfort, although often temporary, of directly affected groups. We have basically stated as a society that future water needs must be anticipated and careful planning used to develop water sources which are often created prior to critical need for the water. As a society, we have basically agreed that provisions for the common good is justified even when a social cost is attached to the action for those directly affected by the decision-making process. What I am suggesting is that the American people have basically accepted the position that when the advancement of the group is partially dependent upon some sacrifice from a portion of the group, then the sacrifice should be made. This philosophy has been operative in terms of water shed development, highway construction, urban renewal and other imminent domain projects and comes not from the benefits occurring the local community, but from benefits to the region. In fact, the benefits may be mostly downstream or exogenous to the directly affected community in terms of flood control and major use of recreational facilities especially if the project is close to an urban community. This is often true of water supply as well, since affected groups may be quite small and have adequate water supplies.

This discussion has led to a major question concerning waste water disposal which must be addressed in determining what type of response land acquisition will elicit from a subject group by the input of exogenously proposed change. The question to be addressed is: Do locally generated

problems which result from successful achievement of societal goals deserve the same consideration as resource exploitation to achieve the goals? The answer to this question will fairly well determine what alternatives a group has in involving other groups in their localized problems. Should a community which has been successful in achieving societal goals (industrial development, provision of services, provision of a basically "good life" for its inhabitants, etc.) but in doing so has also generated numerous other problems be entirely responsible for the resolution of its problems? We have stated as a society that we will collectively provide resources to achieve the goals of socio-economic maturation (provide adequate water sources, for example) but have not made a similar commitment in terms of collective treatment of problems resulting from successful achievement of goals (we may be moving in this direction now in terms of federal grants to control pollution problems and other externalities of community development).

If a developmental group replies to the above mentioned question that a community must bear the burden of problem solving on the local level, then the means of solving the problem are severely limited. This would mean that a community must resolve its waste disposal problems alone and confine the disruptive effects of the corrective action to the local community. In the context of the Three Rivers Project this would mean that the urban communities must develop tertiary treatment plants to handle their waste water and procure stormwater holding areas from within the community. Extra community involvement would not be an alternative in this instance.

If on the other hand the developers perceive the disposal of local waste as being a regional problem then the number of alternatives for action

is greatly enhanced. Regional land procurement outside of the community experiencing a particular problem is within the realm of consideration. Combinations of inter- and intra-community action are also possible.

If the latter position is taken that regional groups must share some part of the responsibility for correcting problems which arise for specific communities, then the problem presents itself in terms of who should bear what part of the socio-economic consequences of the problems resulting from success in building a high-scale society. Should the communities that are generating the major portion of the wastes suffer the greatest portion of economic and social costs to correct the problem or should these costs be distributed on some more equal basis among the regional groups.

The rationale for regional sharing of social and economic costs is that subcommunities outside of the major urban centers are sharing in the regional growth being generated in the major urban center. It would follow that the rural and fringe communities are benefiting from the urban growth indirectly (jobs, new businesses, and other growth factors) and should assume part of the responsibility to correct problems which may arise from continual socio-economic growth in the urban center. It could also be argued that unless the urban center is able to resolve its sewage problems (other problems could also be addressed in this manner) then the subcommunities and surrounding farm lands may be negatively affected by pollution. In this regard, regional action may be justified since prevention of water pollution may be perceived by local communities not presently experiencing disposal problems of waste water as having a positive effect upon their communities.

Within this discussion, we have been suggesting that perception of the

rationale of the proposed project is an important factor in determining the reaction of individuals and groups to the action. While developers may be attempting to reduce the degree of social disruption and economic costs of resolving community problems, the difficulties encountered in the implementation of the program may prevent the achievement of this goal.

If the attitude of the region's people is that local community groups must bear the burden of waste disposal then the probability is high that resistance will be encountered when regional attempts are made to resolve the problem. Residents of Community A will feel that the problem is Community B's and should be resolved in Community B and that they should not be required to sacrifice limited resources to help resolve a problem that they do not believe to be theirs. If the developmental group should propose a program in Community A that requires procurement of land (change land use in Community A) for resolution of a problem created in Community B, it is highly probable that the residents in Community B will resist unless they are made aware of the project.

It should be noted, however, that provision of information about the importance of the project will not ensure that a project will be accepted by the directly affected groups and reduce resistance. Studies among residents affected by watershed projects has revealed that even in communities where considerable information was provided about the project there were severe apprehensions noted. Even where considerable information had been disseminated by the change agent, the people still feared the uncertainties associated with physical relocation. This suggests that most projects which will result in major dislocation of population will be met with resistance. The magnitude of the resistance should vary positively with the magnitude of the relocation. If one were to derive a generalization to

be applied to forced relocation of population then the following may be appropriate: Developmental projects which require relocation of population should be designed to minimize the dislocation of population. This generalization would suggest that the various alternatives presented in the Three Rivers Project Plans will be resisted partially in terms of number of people directly affected. It would follow that the plans which require the greatest displacement of population within contiguous communities will be most strongly resisted.

It should be noted at this point that the above mentioned factor may pre-empt the use of land filtration systems in close proximity to or within urban communities. In compacted urban or suburban areas the number of family units which would have to be relocated could be extensive with concomitant difficulty in reintegration of neighborhoods. Urban renewal studies demonstrate that people perceive their communities as being desirable places in which to live even when by most middle-class standards it may be defined as low in desirability. People become identified and social-psychologically attached to their neighborhoods (both urban and rural) and to their properties. Physical displacement will result in disruption of the established interaction patterns which may be impossible to reproduce. It is therefore argued that: Resistance to developmental projects is a partial function of degree of identification with place of residence and the people within the community. As community identification increases there will be concomitant increase in resistance to disruption. Resistance is also a function of the degree of probability that the established interaction patterns in the community will be reinstituted upon completion of the resettlement. Work in several watershed projects clearly isolated the importance of community identification in terms of response to

watershed projects which necessitated population dislocation. Similar findings were also noted in a study of forced relocation in a community affected by a research center being located in North Central Ohio.

Reintegration of dislocated neighborhoods may be quite difficult in compacted urban centers since the available acreage for collective resettlement is often lacking. Extensive land acquisition would have impact upon fewer people in rural areas in terms of people being relocated but occupational change could have greater repercussions. People in the urban community who were required to relocate would probably not change occupational pursuits since their livelihood is probably not directly associated with land use while the rural farm community would quickly be affected by changing occupations due to watershed or waste water disposal plans which require land procurement.

A factor closely aligned to community identification and occupational pursuits is degree of outmigration and age structure of the community. These two factors could be very significant in determining community response to physical relocation. A study in Kentucky (Brudge and Ludtke, 1970) suggested that areas having extensive outmigration and younger population may be good areas for locating developmental projects which require extensive land procurement. Napier's (1972) and Napier and Wright's (1972) work have also demonstrated the importance of community identification with the group and satisfaction with services existing in the community as being important factors in determining residents' response to community changes resulting from physical displacement of population. All of these findings suggest the following: Resistance to developmental projects is a partial function of characteristics of population to be relocated. Older, established populations which have long

established interaction patterns, who are identified with their community and properties, who are not physically mobile (desire to move for social and economic improvement) and populations which are basically satisfied with the services provided in their community will probably be the strongest resistors to change. While the developmental agency may not perceive its role as including reintegration of displaced people, the probability of extensive and rapid social and technological change being accepted by directly affected groups would be greatly enhanced if reintegration was a major component of the proposed program. It would appear that if a group or a segment of a group makes certain collective decisions which have negative effects upon another segment of the group or exogenous group, then the responsibility for easing the negative effects must be assumed by the decision-making body. What we are suggesting is that if a community elects to procure properties from another community in the region for the benefit of the group procuring the land or for the region, then the benefiting segment of the group should share in the responsibility for reintegration of the displaced people in the directly affected community. If the group to be displaced is made aware of the fact that extensive efforts will be made to reintegrate them back into the group from which they were removed, then the potential resistance to the proposed change would tend to be lessened. If established interaction patterns become extensively disrupted with little attempts to restructure them then more resistance to proposed change can be anticipated.

One factor that must be considered in terms of predicting response to physical displacement of people is the perception that the subject group has toward the importance of the project requiring land acquisition. The directly affected group must be convinced that the project will make signifi-

cant contribution to the socio-economic well-being of the collective group (either community or region). If the project is localized and many people perceive the degree of need for the project to maintain community viability, there will be greater probability that resistance to the project will be lessened. This does not mean that people will be pleased to move but it does suggest that people will be more willing to accept the project than if the necessity of the project is unknown. In this regard, the plans which advocate local tertiary treatment of waste water with limited land procured for sedimentation of storm water will be more rapidly accepted. If the plans which require vast acreage for land irrigation with secondary treated waste water should be implemented, they should be initiated as close to the urban area experiencing the problem as possible. This is based upon the position that the closer an affected group is to the origin of the problem, the greater the understanding of the need for the sacrifice for regional growth which should lead to a lessening of the negative attitudes toward the project and physical relocation of population.

An important factor in terms of the groups' acceptance of a project such as the land irrigation sewage plan will be the groups' perception of what the project will do for their "own" community. It is one thing to argue for increased socio-economic viability of the region and to demonstrate to the affected group how the "trickle-down" theory will work for them (if the region grows, then the community will grow). It is another matter to tell a group that your community will suffer population dislocation with little probability that resettlement in the area is possible which will mean permanent negative effect on your community. If the treatment lagoons are perceived as being negative additions to the area and people do not

desire to resettle or to settle near them, then the potential exists for strong resistance to the project among directly affected groups. We are suggesting that response to the projects will be a partial function of what the people see the impact of the project having for their community whether or not the perceptions are based on valid information or only perceived facts which may be invalid. Research should be conducted to determine what the attitudes of the people are in the area of the treatment lagoons toward the projects and determine the factors associated with the negative or positive attitudes (a study using Napier's (1972) and Napier and Wright's (1972) research instrumentation and techniques should be most enlightening relative to the social psychological response to this type of developmental project).

While previous studies of forced relocation demonstrated that community residents were not alienated from their community as a result of watershed development, urban renewal and land acquisition due to a state research center developmental project, the situation of waste water treatment lagoons may not be the same. If the subject groups perceive the lagoons as being negative in nature (open sewage pits, for example), the people may develop severe negative attitudes toward their community which are a direct function of an undesirable resource being located near their community. If this happens, outmigration should occur (partial function of the individual's means of solving the cognitive dissonance conflict with living in a community which he believes to be unable to satisfy his needs) and subsequent decline of the affected communities. Such a situation could have long-run implications for future projects of the land irrigation sewage treatment type. Other groups will evaluate the effects in an area which has used the land treatment concept and, if the results are negative in one area, considerable

resistance will occur in other proposed regions or areas of the same region if the program must be expanded. One effective mechanism for relieving anxiety and enhancing the potential for lessening of resistance would be the presentation of results from other such projects if they exist. The research findings from other areas or regions should be provided to the potentially affected groups even if the results of the evaluations are negative. The change agent, however, should be prepared to explain the negative results and demonstrate how the negative aspects can be reversed if the social and physical situation in the subject community is similar to previously developed areas.

Above all things, the subject group should be completely informed of all factors associated with the developmental effort, both potentially positive and potentially negative consequences. The subject group should have a major role in decision making and program development. Napier's (1972) evaluation efforts of the impact of exogenous change clearly demonstrated that a major factor which increased resistance development was that exogenous change was imposed upon the group. People frequently noted that "outsiders" had imposed their will upon the group. To negate this potential alienating factor (negative response to development), the group must feel the program is partially "theirs" in that the local group has a commitment to the project and will work to make the project function effectively. To achieve this goal, local people must have significant role in program development, implementation, and operation.

Concerns about the Environment: Unlike watershed development on some other localized developmental project, the land irrigation sewage treatment project will have a very significant compounding factor that may generate

potential resistance to the project. The design of the program necessitates transportation of secondary treated sewage over considerable distance by pipeline or some other similar conveyance. Problems of water pollution have received much attention in recent years and the potential would appear to exist for considerable secondary treated waste water to be accidentally discharged upon public or private lands and waterways. It would not be surprising for considerable resistance to the project to be generated among local community groups and individual land owners in close proximity to the sewage transportation system. The resistance to the program may not be confined to local people but receive considerable attention from conservation groups throughout the region or state. If this should happen, the external (outside of the region) groups' actions will complicate the program implementation considerably and generate more negative feelings among local directly affected people. It is highly probable that concerned groups external to the affected community could serve as stimulators of resistance and provide the leadership for organized opposition to the project. This could be a very important factor in elevating resistance to any developmental project especially in areas lacking strong community infra-structure (social organization). A study in Mississippi (Wilkenson, 1966) clearly noted the importance of local community social structure in the acceptance of watershed projects. Communities which had extensively developed social structure exhibited the highest degree of resistance to the water resource development. This suggests that areas without extensive social organization there may not be the strong commitment to the community which has been shown to be very significant in the explanation of resistance or lack of resistance to community change. Wilkenson's findings suggest that agencies

desiring to decrease negative attitudes and reduce resistance to projects of land acquisition should seek communities with as little social organization as possible.

CHAPTER III

ALTERNATIVE LAND DISPOSAL CONCEPT: PLAN B EXTENDED

In light of the non-acceptability of Plan C, (land treatment in the Western basin) but yet because of the cost effectiveness of land treatment as an alternative method of meeting Level II standards, the desirability of incorporating land treatment into the overall plan for the Three Rivers Watershed is affirmed. It is recognized that Plan B does utilize in-basin land treatment as well as advanced biological and physical-chemical treatment facilities. Extending the land treatment phase of Plan B to include all soil types, topographies and vegetative covers and applying effluent at a rate acceptable to the particular site, makes available portions of land ruled out by the contractors. This use of all available soils is the core of Plan B-Extended. The following is a discussion of various aspects of extending Plan B.

Justification

The disruptive effect on the economic and social life of the Western Basin was a major factor in the non-acceptability of Plan C, as stated in the previous chapter. In order for land treatment to be acceptable, it should be non-disruptive with respect to relocating people and communities, to the tax structure and to job availabilities. Plan B can have minimum disruption for the following reasons:

(1) Many smaller treatment areas will be used so that relocation of people and communities will be minimized.

(2) Secondary treatment lagoons will be smaller and located near the sewage source, so that the aesthetic problem of receiving someone else's sewage will be avoided.

(3) Land treatment can be initiated in stages so that as cropland is used for land treatment, new farming practices can develop, e.g. grassland-beef.

(4) Land acquisition (buy or lease) for treatment will be in smaller increments and needed educational promotion can precede acquisition.

Implimentation

A significant feature of Plan B-Extended is that implimentation can proceed in stages or steps. A combination of advanced biological, physical-chemical and land treatment methods can be used. A desirable feature of a step-wise plan is that an early site can be used for research and development of procedures and equipment. Also the early site can be used in public education to demonstrate the acceptability of land treatment.

Even with the advanced biological or physical treatment plants that will be used in the near future, the land treatment phase can be expanded as these plants become obsolete.

The development of a Sewage District for the Three Rivers Watershed would be a useful tool to impliment Plan B-Extended. A key to the success of such a land treatment system will lie in effective management to the point of deciding which sites will be irrigated at what time.

It will be highly desireable that inputs into the management decision come from soil scientists, agronomists, agricultural engineers, fish and wildlife personnel, agricultural economists and rural sociologists.

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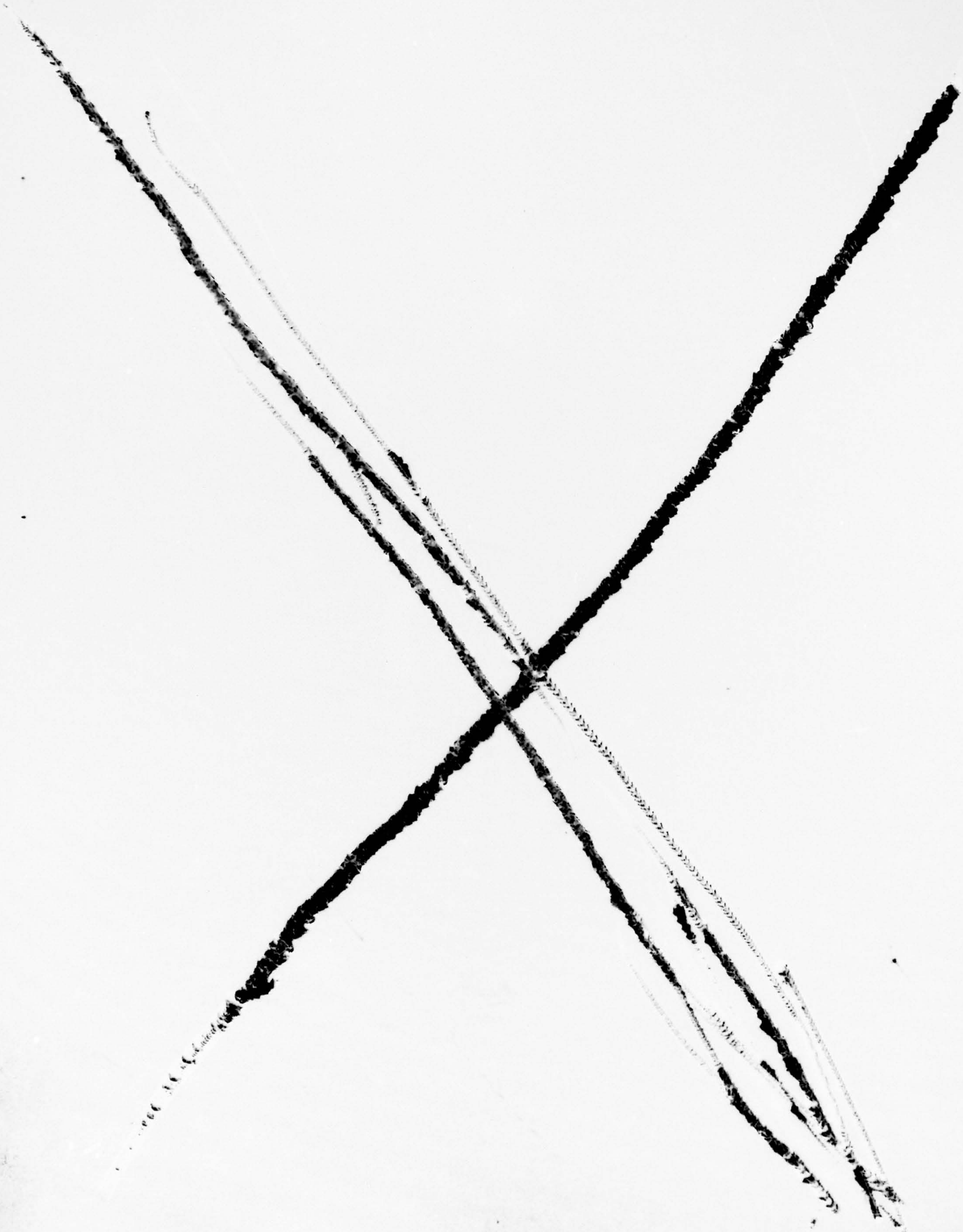

Monitoring the discharge from land treatment sites is essential and this data should be used in management decisions.

Land treatment within the Three Rivers Watershed will require land use rights over an extended period of time. In proximity to metropolitan areas, difficulty can be expected in achieving land use rights over long periods of time as the landowner may wish to maintain the right to sell the land for non-agricultural uses. This factor could necessitate purchasing such land as treatment sites. It might then be utilized as "green belt" or recreational space.

Zoning serves in many areas as one effective land use tool, but it has a significant limitation. Zoning is subject to change, particularly where agricultural land is involved. Therefore, land zoned agriculturally and used for land treatment may require additional regulations to prevent usurpation for another use.

Description

Plan B-Extended is based on the availability of adequate land to accept the effluent. Some of the usual concerns with soil selection have already been discussed in the Wastewater Management Study, Appendix 5, Phase I, and are valued considerations. The criteria used by the committee has extended on these points and is based on the premise that almost all soils can be used to renovate some effluent if managed properly. The usual restraints provided by poor infiltration rates and permeability of the fine textured soils and the excellent infiltration but poor renovative properties of sandy course textured soils are then removed or at least minimized. Likewise, forested areas or soils on sloping terrains are considered potentially useful if managed properly. The only soils areas

which should be excluded are organic soils and those soils which are shallow and underlain by porous bedrock.

The quantity of land needed within the Three Rivers Watershed to provide a land treatment area equivalent to that proposed in Plan C has been estimated in the following manner.

The Wastewater Management Study, Draft Summary Report, May, 1973, indicates that 53×10^9 gal/year of urban stormwater runoff and 234×10^9 gal/year of municipal/industrial wastewater is scheduled for land disposal (Plan C) in the year 2020. This combined volume of 287×10^9 gal/year is equivalent to 105×10^5 acre inches of water. Application of 20 inches/acre/year would require 525,000 acres of l[illegible] obviously 262,500 acres would be required if an average of 40 inches of effluent is applied per acre per year. The average maximum of 40 inches/acre/year reflects the concern that fine textured soils in the humid, temperate climate of Ohio are incapable of receiving more than this average quantity of water and retaining a well aerated root zone even though provided with subsurface drainage. For further elaboration and substantiations of this concern, see Land Treatment of Wastewater in Southeastern Michigan, U.S. Army Corps of Engineers, 1973.

The quantity of land potentially available in the seven counties which are located at least partly in the Three Rivers Watershed are shown in Table 10. The area of cropland, pasture and forest would total 1,101,251 acres. Meeting our land requirements of 262,500 acres as projected in the previous paragraph would require 24% of this area. Whether this amount of land could be obtained by lease, purchase or other contractual arrangement must remain an open question. The acreage estimates above do not include park land, golf courses, government land, or other recreational areas which might be used for effluent renovation.

A further breakdown of these soils with respect to drainage is shown

TABLE 10. LAND USE IN THREE RIVERS WATERSHED AREA

1967 Ohio Soil and Water Conservation Needs Inventory

COUNTIES	TOTAL LAND AREA	CROPLAND	ACRES IN CROPLAND NEEDING DRAINAGE	PASTURE	FOREST	OTHER
Cuyahoga	291,840	15,245	7,000	1,000	32,445	6,953
Geauga	259,080	80,591	22,000	19,057	100,663	25,676
Lake	148,480	33,625	6,000	2,915	35,588	15,916
Lorain	316,800	151,339	74,000	21,154	49,656	45,951
Medina	271,200	148,558	76,000	24,739	41,814	34,897
Portage	319,320	115,622	39,000	32,053	89,327	21,892
Summit	264,229	53,366	9,000	6,083	46,411	33,027
	1,870,949	598,346	233,000	107,001	395,904	184,312

in Tables 11 and 12. The soils in Table 10 are those well and moderately well drained medium textured soils (even without subsurface drainage) on sloping topography. These soils would be expected to accept the highest applications of waste effluents. An additional number of soils (Table 11) are fine and medium textured, poorly drained, on gently sloping or nearly flat topography. These soils would require more extensive management and drainage to make them accept even small applications of waste effluents.

Table 11. Well and Moderately Well-Drained Soils in Cropland, Pasture, and Forestry Uses as of 1967, Based on Conservation Needs Inventory

Counties	Land Area-AC
Lorain	61,000
Medina	130,000
Summit	80,000
Portage	144,000
Geauga	110,000
Lake	39,000
Total	564,000

Table 12. Poorly and Very Poorly Drained Soils in Cropland and Pasture Uses as of 1967 Based on Conservation Needs Inventory

Counties	Land Area-AC
Lorain	27,000
Medina	39,000
Summit	8,000
Portage	27,000
Geauga	28,000
Lake	8,000
Total	137,000

In the application of effluent to the land it can be expected that the use of center-pivot systems will be less suitable. Particularly in wooded areas the used of fixed sets, either spray nozzles or gated pipes, will need to be used. A must in application is to obtain even coverage of the land surface. Where overall topography is suited, the overland flow method may be the most suitable particularly with stormwater runoff, e.g., forested land.

Adequate storage must be designed into the system to receive effluent and stormwater runoff when land application is not suitable. The treatment lagoons used as part of secondary treatment may be designed to provide some storage. During winter operations, if the effluent from the plant can be irrigated on the land, bypassing storage lagoons, there will be less freezing and ice build-up problems.

Subsurface drainage will need to be designed in the system where croplands are used. By using low annual application rates, scheduling of application can be done to avoid planting and harvesting times.

Wildlife Alternatives

Fish and Wildlife: Land treatment within the Three Rivers basin is more attractive to fish and wildlife interests than plans for treating various proportions of the total wastewater at western sites for two reasons: (1) Sludge will be collected in an area where it can be transported economically to surface-mine areas for reclamation of this land, thereby enhancing fish and wildlife in these degraded areas: (2) Enhancement of low flows, general water quality and reduced silt loading of the Rocky, Cuyahoga and Chagrin Rivers, all of which empty into the Central Basin of

Lake Erie, would make them prime candidates for the establishment of anadromous salmonids (the Chagrin River is currently of sufficiently high quality that anadromous salmonids are stocked into it).

Demonstration of enhancement for the production of upland game should be possible in forested and grassland treatment areas. The relative small acreages involved will preclude the possibility of any streams sufficiently large to support an appreciable stock and range of fish species. Although the methods used for improvement in water quality may be demonstrated on small watersheds, the demonstration of enhancement to larger streams will require larger acreages under wastewater management, which might occur as land treatment areas increase in a stepwise manner.

One possibility for the enhancement of fishery resources in rather small basins would be the construction of a reservoir in the lower end of the basin. Although the consultant reports discuss nutrient recycling extensively, water recycling is largely ignored. This is a very real possibility in cases where land treatment areas for wastewater are located within the basin of a municipal water supply (stream or reservoir). Plans for land treatment of Akron's wastewater would result in this type of recycling as well as other communities whose water is taken from the ground or from streams and rivers in the Three River Watershed.

Community Perception and Acceptance

Community perception and acceptance should be approached by first recognizing that local citizens by and large appear to question whether or not they will be given a voice in determing the final outcome of any plans under consideration.

It also must be recognized that in the final analysis acceptability or non-acceptability of this type concept to a major extent rests on whether or not the citizens of the local community are actively involved in the decision with regard to any alternative.

The concept will likely only be workable if people at the local level have confidence in the plan and decide that it should be tried. Care must be taken to recognize that the program is primarily a societal question or decision and not a program to be imposed upon them without due regard for the political process. Ultimately the decision to accept or reject a plan of this nature should be made by the people at some level, i.e., township, county, or multi-county level of responsibility. Thus every effort must be made by all agencies involved to maintain a high degree of credibility and at all times keep people adequately informed and consulted on matters that have bearing on the project before final decisions are made.

A number of observations collected as the result of interviews with individuals who reside in North Central Ohio have bearing on any educational or informational program that might be developed. These observations are as follows:

1. At the present time there are many unanswered questions regarding the implications of using the system which understandably causes large numbers of citizens in North Central Ohio to react negatively to the entire land disposal concept.
2. There are enough possible negative results (both real or imagined) in using the system that large number of people are against taking a chance on it even to the extent of appearing to be against discussing the merits of the idea.

3. Information on the proposal thus far has been of a highly technical and fragmented nature to the extent that most citizens do not understand and thus do not trust the stated purpose of the work done thus far by the Corps.
4. Community involvement in the decision-making process regarding the implementation of any project is essential. Local citizens will be able to provide information to improve the implementation of any project under consideration.
5. There should exist a continuous open discussion of the probable consequences of the developmental project on a regional and local [illegible]. Both positive and negative effects should be presented to [illegible] subject groups.
6. Developmental agency personnel should treat groups and individuals involved as peers and not as subordinates. The need exists to establish more empathy and rapport with the people.
7. Provision should be made to adequately compensate people for problems created among directly affected groups. All possible consequences cannot be anticipated and if the group realizes that the uncertainties are being reduced resistance should be lessened.
8. Resistance may be lessened if the subject group is convinced that the newly created resource will not lead to a deterioration of the community. For example, if the group perceives the lagoons as potentially resulting in the destruction of the aesthetic beauty of the community, then severe resistance to the project will be forthcoming. The group must be given information relative to the odor potential, health hazards, recreational develop-

ment potential and other relavant data about potential utilization of the treatment ponds.

9. In order to be acceptable in local communities the concept must be proven not to adversely affect farmers nor disrupt present farming systems to any large extent, unless an economic advantage can be shown, including present patterns of individual land ownership.

As discussed in detail earlier in this report, one possibility to minimize disruption of present farming systems would be to vary the amount of moisture that would supplied to the soil. Varying the inches of effluent would make it possible to include additional types of soil and also increase the types of agricultural practices that would be feasible. Thus the large array of problems or disruptions anticipated by expected changes in farming practices could be substantially reduced. This option would increase the total number of areas required but could also change the area in which land treatment would be possible. Varying the amount of effluent applied would result in increasing the acreage adapted to land treatment within the Three Rivers Watershed or any other area that might be under consideration. Thus in North Central Ohio, as well as in the remainder of the state, the land treatment concept could be used to assist small and medium sized communities to solve their own sewage problems.

Given the above situation the following considerations with regard to an educational program are recommended:

1. Educational materials must be developed which (a) clearly and concisely state current status of the effects of the Corps and the State of Ohio and indicate likely future possible sequence of events, (b) depict what information is of a specific nature and which can be generalized upon, (c) clearly outline the

practical alternatives involving land treatment and supply a means or outline to permit local citizens to evaluate these alternatives before final recommendations are made. This will require a simplified analysis of the pros and cons of each alternative. This information should include not only the technical aspects but the social, economic and political aspects as well.

2. Those involved in an educational program should not try to "sell" any one proposed alternative. (Every effort must be made to provide local citizens opportunities to make choices.) Any educational effort should let it be known early that its main function is to disseminate information and provide an objective forum for discussion of the various alternatives in dealing with the whole question of distribution of secondary effluent. After this is accepted, then the resources of the colleges and state and local agencies should be made available to the local people to provide them with answers to any questions that resource people can effectively relate to. This question would be considered then very much the same as any other public affairs issue. It should be recognized by all of us that the public can effectively deal with public issues even though frequently these issues are controversial in nature.

The educational program should be effective enough in the presentation of facts that people recognize its objectivity. This becomes even more important as public issues become more sensitive. Special efforts must be made to differentiate between facts and opinions. It is quite appropriate to include

both facts and opinions in a teaching program as long as the public can clearly distinguish between the two. Above all, the people need to have a source of information which can provide them with the objectivity that is so necessary and yet sometimes so difficult to achieve.

3. Land treatment projects for small communities should be considered in order to demonstrate the effects of the transmission and disposal of secondary effluent on land. The effects of sludge disposal through application to agricultural land must also be demonstrated. Because of the uncertainties involved in such a demonstrational project, the effort should be partially funded from sources outside the community.

4. An educational or information program should accompany the establishment of a demonstrational project. A program should be one where the problem is clearly identified; where factual information regarding alternative solutions is presented; where a forum is provided for input by all interested parties and where in the final analysis the decision of which alternative is implemented is made by the people. When the problem is as sensitive as the one being considered great effort must be made to make certain that all possible factual information relating to the issue is made public. Where information exists that is based on misunderstanding, then a conscious effort must be made to provide facts that can be substantiated and presented in a manner that provides clarity for all interested groups or individuals. For some questions, at various times, there will not be facts available to provide an answer other than "I don't know." When this situation

arises the lack of facts must be recognized and followed with an examination of what is needed to close the information gap. It may be the kind of information that only can be obtained through demonstration via a demonstrational project.

All parties involved must expect: factual information that will be made easily available; the opportunity to provide input and the right to accept or reject various alternatives. At the same time all parties involved must be: tolerant toward the thoughts of each other; certain that information provided is factual; and conscious of short and long-run economic and social cost benefits involved in all alternatives considered.

Specifically the educational program must at the outset involve local people in a planning committee to plan methods to be used, such as mass media, mail box information, group meetings, tours, demonstrations, etc., as well as determine the structure of the methods utilized. The planning committee would therefore be a very important component of the educational program. Obviously, the committee should include a broad representation of groups and attempt to insure that all interests are included.

Should the planning committee decide to use the group meeting as one instrument of education, considerable work will be required before the meeting to include such aspects as the following: planning the agenda, determining what subject matter should be included and who can best present the information, the date, time and place of the meeting, consider if a series of meetings will be required, adequately inform the public of the meeting and consider what, if any, costs will be involved. These are minute details, perhaps, but also vitally important aspects in conducting

an effective educational program. The meeting agenda may include presentations by such people as local officials, university faculty, Ohio Agricultural Research and Development Center representatives, representatives of the Corps, Cooperative Extension Service faculty, representatives of agencies of the State of Ohio, members of local groups and consulting firms. The meeting should also provide ample opportunity for discussion and exchange of ideas and concerns. It must not leave the group "hanging" but provide an answer for "Where do we go from here?" This step is extremely important to the solution of any problem. Key words throughout any of the methods mentioned are: involvement, openness, discussion, tolerance, facts, alternatives, benefits, costs, and local decision-makers.

Another important aspect of any educational effort would include keeping all USDA agencies and their staff informed and involved in any demonstrational project which includes the distribution of secondary effluent on agricultural land. The County USDA Committee, usually composed of local, state and federal agency representatives interested in community development, would be in an excellent position to provide a technical input with regard to such questions as soils and related matters, economics, livestock and crop production alternatives and financing of the various alternatives. Other possible contributions from this group include helping to evaluate the acceptability of the whole idea and presenting it to the citizens of the community.

The USDA Committee approach with this project would be the same as with any other community development project they might become involved with in the county. This includes making appropriate contacts with local officials

to assure that the agricultural interests and impacts are properly considered as this community development project unfolds. Local USDA Committees could most likely be involved working primarily with local officials in providing them with their expertise and encouragement to carefully examine all sides of the question.

The early involvement of USDA agencies and their field staffs should be considered as being vital in view of their frequent contact with the public and thus the need to be fully informed as they attempt to answer the questions and concerns of the public.

5. Within a demonstration land treatment project for small and medium communities, information should be clearly provided to the citizens as to precisely what is to be demonstrated and the types of information that will be collected and evaluated. These include such information as follows (Napier, 1973):

    a. The effect of the secondary effluent on crop and livestock system, water and air quality, costs of the system, land control arrangements that will work and the social acceptability of such a system within the community.

    b. Evaluation of the social-psychological perception of the proposed change by the directly affected groups.

    c. Evaluation of changing attitudes of residents toward the directly affected community.

    d. Evaluation of the attitudes held by local residents toward the change agent and the project.

    e. A minimum four year study of the impact upon the total social structure of the community--the political, social, and economic institutions.

    f. Evaluation of the short-run and long-run effects of land use change upon the political, social, and economic institutions of the community.

g. Evaluation of the population changes occurring within the directly affected community groups which are attributable to the proposed waste treatment program.

h. The changing value orientation of people should be studied with emphasis placed upon potential consequences.

i. Analysis of the factors associated with rapid intergration of the community group should be conducted.

Land treatment projects being discussed at the present time should involve relatively small communities and consequently require small acreages to handle the land treatment needs. For example, a community of 10,000 people would require approximately 400 acres. While this size of project could effectively demonstrate many of the technical aspects of such an approach it would have some limitations in applying the results of a small scale project to one of significantly larger scale from the standpoint of societal impact and acceptance. While local citizens would be able to evaluate the demonstration for that area, the societal and economic impacts of larger scale projects would remain in part unanswered.

These include as factors as the:[1]

1. Relocation of families.
2. Effect on property tax base.
3. Attitude and reaction of area residents - farm and residential families.
4. Attitude of persons and businesses outside the affected community.
5. Effect of different types of land ownership.

In summary, the subject of community acceptance, whether the land treatment project is relatively large or small, rests upon the wishes or decision of the community involved. In preparing itself to make the decision, the educational approach used by the community will be critical. The decision to accept or reject, as in other community issues, should be made after full knowledge of immediate and long run consequences.

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[1] Dr. Ted L. Napier, Rural Sociologist, The Ohio Agricultural Research and Development Center and The Ohio State University, addresses many of these factors in depth.

CHAPTER IV

LAND TREATMENT PROJECTS FOR SMALL AND MEDIUM SIZED COMMUNITIES

In our evaluation of the technical reports, we have enumerated several problems that exist with large-scale land treatment. These problems included agronomic, engineering, and economic and social factors. In the design of land treatment projects for small and medium sized communities, certain management and operating parameters need to be evaluated in order to determine the "best" system for a particular community. In addition, this information may be used to project design, management and operating consideration for larger land treatment systems.

Therefore, it is imperative that various aspects of land treatment systems, such as those at Bucyrus, Willard, Bowling Green, Burton or Medina County, be monitored and evaluated. Parameters for monitoring and evaluation are suggested in the following sections.

Agronomic Aspects of Evaluation and Monitoring

A system of disposal of secondary effluent on land depends on the physical, chemical and biological components of the soil collectively functioning as a filter. From experience we know that filters act effectively in removing some constituents from the material we are filtering while allowing other constituents to pass. This is also true for the soil filter when it is utilized to remove unwanted inorganic and organic materials from secondary effluent (renovation). There are some potential problems

(leaks in the filter) associated with land disposal which must be considered. Likewise the capability of the soil filter in many respects far exceeds that of conventional waste treatment systems and thus must be considered a viable and useful alternative to conventional waste treatment. Some of the problems correctly or incorrectly associated with land disposal require further evaluation before final decisions on benefits of waste renovation by land disposal can be made.

The measurement of the following agronomic parameters are considered to be important.

<u>Preparatory Soil Characterization</u>

a) Provide a detailed soil survey of project area if one is not already available.

b) Collect several profiles for each of the major soils in the project area for routine chemical and clay mineralogical analyses. These data will provide background reference points for soil chemical properties prior to treatment (Profiles in tile backfill should also be sampled). Measured chemical properties would be the soil content of carbon, nitrogen, phosphorus, heavy metals and other inorganic ions of significance to waste renovation, cation exchange capacity and mechanical analysis.

c) Samples should be collected at key sites (both in backfill material over drainage tile and in adjacent undisturbed soil) for micromorphology characterization.

d) Construct a close interval elevation survey of at least a portion of the project area so surface relief, and topography of subsurface horizons can be plotted on three dimensional nets.

e) Preliminary determination of physical properties including infiltration, hydraulic conductivity, soil structure and the related aeration and/or oxidation status of the major soils in the project area.

Operational Soil Parameters of Concern

a) Provide appropriate monitoring of changes in soil physical properties (See preparatory parameters of concern) under various soil management, drainage and cropping systems receiving effluent and/or sludge (Emphasize the backfill area of drainage systems).

b) Determine a soil nitrogen balance for the project area which includes the nitrogen distribution in the soil profile, drainage effluent, and harvested vegetation. This data would provide a much needed measure of biological denitrification losses under different management systems, and the pollution hazards associated with nitrate nitrogen leaching.

c) Follow the changes in the organic carbon content of the surface soil horizons of the project area. Soil organic carbon compounds (soil humus) are of considerable significance to soil physical properties, to soil reactions of inorganic elements including heavy metals and for the adsorption of possible toxic organic compounds. Thus, changes in organic carbon content with time or system management are of considerable significance.

d) Follow the accumulation, movement, and possible changes in chemical forms of soil phosphorus as influenced by system management and treatment variables. It is important that the total capacity of the soils be evaluated for their long term renovative capacity with respect to phosphorus. Phosphorus should also be monitored in tile effluent and harvested vegetation.

e) Follow the accumulation, movement and changes in the chemical form of various inorganic ions and heavy metals of concern to the success of soil filter. The relationship of percentage of sodium (on the exchange sites) to calcium and magnesium is of considerable significance to the degradation of soil structure and decreased soil infiltration rates. Boron will be of significance because of its expected presence in high concentration in secondary effluents, its potential toxicity to higher plants, and impact on water quality. Heavy metals are of concern because of plant toxicity and uptake or because of their impact on the environment. The particular metals to be studied will depend upon those contained in the effluent. Inorganic ions and heavy metals should also be determined in tile effluent and in harvested vegetation.

f) Potentially toxic organic materials such as detergent residues, industrial waste organics, and pesticides may be of significance to success of the land disposal system. Prior information and analysis of secondary effluents and sludges will indicate which organic compounds might be of concern.

g) Follow changes in clay minerology and soil micromorphological characteristics with time. These evaluations will be of considerable significance to the interpretation of changes in the soil physical and chemical properties of the treated soils.

Operational Cropping Parameters of Concern

Decisions must be made on the particular agronomic or specialty crops most suited to the project area. These decisions should include yield potential, ease of management, resistance to disease and insect

pests, marketability, and renovative capacity for N, P, heavy metals and other inorganic ions. Appropriate field layouts should be included to evaluate the responses of the selected crops to different effluent application rates, irrigation frequency soils, tillage systems, harvesting frequency, and drainage systems. Based on previous feasibility reports and discussions (See Appendix A) initial plant selections should include Reed Canarygrass, tall fescue, ladino clover, corn, turf grasses, and nursery stock.

Throughout the duration of the research, insect, pathogen, and weed populations must be monitored. An evaluation of methodology of pest control e.g. application of pesticides in irrigation water must be an integral part of site management.

Soil Microbiological Aspects

Survival of pathogenic viruses and bacteria after chlorination or ozonation would be of considerable importance. Routine surveys should be made for survival in the soil of indicator bacteria as well as viruses.

Engineering Aspects of Evaluation

Using data from the soils and cropping study of the treatment site, engineering design can proceed. The technology of irrigation and drainage is well developed and needs little evaluation except to see that a uniform application of effluent on the land occurs.

In addition to monitoring the chemical constituents of tile effluent and ground water, discussed in the previous section, it would be desirable to measure tile flow from the treatment site to be able to calculate ground water recharge. It was recommended that a larger drainage coefficient be used for subsurface drainage of the treatment site. This would in part

require closer drain spacings. It would be desirable to initially use several spacings for a particular soil, and determine the "best" spacing for that soil with a particular cropping pattern. The tile flow would also be needed to evaluate the drainage coefficient.

Related to flow from the tile system is the surface flow from the treatment site watershed. Provision needs to be made for measuring total surface flow from the treatment site watershed where an USGS stream flow station is in proximity to the treatment site, the change in the hydrological characteristic should be evaluated, particularly with relation to storm hydrographs and stream augmentation at low flows.

The overland flow method of application could be used, particularly in wooded areas. The effectiveness of treatment with the overland flow method would need to be determined with relation to the soil, vegetation, slope and length of slope. Then design criteria for overland flow can be developed for land disposal for conditions in Northern Ohio.

Designing Wildlife Benefits

The management of water for wildlife (fish and game) must begin at the time and place it falls upon the ground. Thus, it is important that all lands contributing run-off upstream from the area in question are brought under proper management. Improper management of as little as 10% of the total area of a basin could largely negate the benefits expected from properly managing the remaining 90%.

With regard to stream ecology, the areas of silting (agricultural run-off and stream bank erosion), water temperature, and minimum flows are all factors to be considered when designing wildlife benefits into the total wastewater management plan and objective. Pollution from municipal

and industrial sources will assumedly not be a factor at a time when land treatment of wastewater is in practice.

Silt Reduction

The benefits of reducing stream silt loads extend far beyond enhancement for wildlife purposes alone; the frequency (and cost) of harbor dredging is reduced, the cost of purifying municipal water supplies drawn from a stream (or a reservoir) is reduced, the useful life of downstream reservoirs is increased and perhaps most important, valuable top soil is retained on the watershed for plant production. Although it would be desirable to give attention to all sources of stream silt loading within the watershed that wastewater is being land treated, it is probable that only agricultural run-off and riparian erosion would fall within the jurisdiction of the wastewater management body.

Riparian Erosion: The erosion of many stream banks stripped of woody vegetation contributes significantly to both the silting of their waters and the destruction of fish habitat. Although most of the riparian woody vegetation that has been stripped was done so in order to create additional agricultural land, the acreages currently being lost to stream bank erosion cast doubt as to whether this gain is real when long term usage is considered.

The ecological benefits of riparian woody vegetation are three-fold; stream banks are anchored better by trees than by grass cover, the velocity of the stream and therefore its erosion capacity along its banks is reduced during periods of high flow due to impedence from tree trunks, and the shading canopy reduces summer water temperatures which may be a critical factor for many of the more desirable fish species. On the negative side,

crops cannot be grown to the stream edge and the probability of lowland flooding is increased due to retarded flow during periods of peak run-off. However, this latter factor would be at least partial off-set by no-tillage practices which reduce the rate of run-off discharge.

There are no set standards or criteria for establishing riparian woody vegetation in denuded areas. Once lost, trees are difficult to establish in the lowland areas because of dense and moderately tall growths of non-woody plants. Reforestation is best accomplished by mowing and planting rapidly growing trees such as cottonwood and willow. Once these have established at least a partial canopy, the more slowly growing species which are of greater value to wildlife such as oak will be able to invade or can be planted with reasonable success. This latter group of trees, once established, will provide long term stream bank protection through natural re-seeding. Some banks which are eroding with almost vertical faces would need to be graded to more moderate slopes before vegetation of any kind could be established.

The distance of riparian forests from the stream border should be at least to the edge of the flood plain where this type of geology exists. Areas not having a flood plain are as a rule currently forested.

As mentioned previously, crops cannot be grown successfully to the flood plain edge if it is bordered by trees. Therefore, a border strip of 25 or more feet in width, depending upon tree heighth and the crop to be raised, would need to be removed from normal agricultural production. A grass-legume cover to provide food, cover and nesting habitat for wildlife could be established in this buffer area. An additional benefit realized would be stream silt load reduction by precipitation from overland run-off through this protective border.

Cropland Erosion: This current source of stream silt loading should be greatly reduced by the no-tillage agricultural practices outlined in the consultant reports. However, in order to maximize wildlife benefits in wastewater land treatment areas, as many as possible of conventional tillage practices should be supplanted by no-tillage agriculture.

Stripmine Reclamation

The benefits of stripmine reclamation for purposes other than fish and wildlife interests are so varied and numerous that they cannot be enumerated here. However, it should be noted that areas which are unproductive for plant-life will also be unproductive for wildlife. It is often said that all animals are plant parasites since the source of nutrition and energy for herbivore and predator alike can ultimately be traced to green plants!

The concept of reclaiming an entire stream basin is again central to the enhancement of stream biota. Reclamation should begin in headwater regions and proceed downstream through the basin. Reclamation in the opposite direction, from stream mouth to headwaters, is much less desirable since streams can remain acid and silt laden from the drainage of unreclaimed upstream areas. Also, efforts should be directed toward reclaiming as much land as possible, using minimal sludge application rates, rather than simply using stripmines as a sludge disposal area by applying massive amounts of sludge per unit area.

Lagoon Fish Culture

The water quality level that will be achieved in wastewater treatment lagoons is unknown at this time. As such, a tentative judgement on the species of fish, if any, that might be raised in these structures is not

possible. Any fish culture that may ultimately be possible in lagoons will require preliminary research of some degree. Facultative Lagoons: These will evidently be drained at intervals in order to remove bottom deposits of sludge. In the event that water quality proves suitable for fish, it should be relatively simple to design and construct an external catch basin for fish harvest in conjunction with the drain or outflow structure. The lagoon bottom should slope toward this structure in order not to strand fish in puddles. Storage Reservoirs: The size, disposition and constructional features of these impoundments are not given in the consultant reports. Their value for fishery interests will probably be quite limited. They will be unsuitable for fish culture and the problems of severe annual fluctuation and bacterial contamination will probably make them unsuitable and/or unproductive for sport fishing. However, too many unknowns exist to allow a final prediction of the value of wastewater storage reservoirs for fisheries. It will be necessary to stock them and to monitor both the fish community and bacterial contamination before a final judgement can be made.

Economic Design

In order to assess the economic impacts of land treatment as it is implemented by small communities, economic as well as engineering data needs to be collected and analyzed. Small community land treatment projects will enable that kind of data to be generated and analyzed. The results will help us to further evaluate larger regional land treatment alternatives and the feasibility or complexity in implementation of such wastewater treatment alternatives.

Land treatment projects for small and medium size communities initially

should be designed such that economic data can be obtained to further analyze and resolve those problems listed in the earlier evaluation and to aid in the implementation of cheaper, more effective wastewater treatment for small and medium size communities.

The economic data needed are:

1. Costs as treatment capacity varies

   a. Construction and engineering
   b. Operating and maintenance
   c. Sewage transport and collection
   d. Effluent irrigation
   e. Local versus grant allocation

2. Benefits

   a. Reductions in sewage costs for the communities
   b. Sale of products from the land area as enterprises vary
   c. Community enhancement
   d. Reduction in resources used for sewage treatment

3. Institutional implementation

   a. Land acquisition
   b. Land acquisition and lease back to farmer
   c. Use right obtained by community from farmer to apply effluent
   d. Demonstration of different farming practices and compatibility with land treatment objectives
   e. Joint operation by several small communities (small scale regionalization)

4. Secondary economic effects

   a. Land prices and evaluation of land values and taxes as a result of land treatment
   b. Measure of profit loss as farm enterprises are converted to be compatible with varying effluent application rates
   c. Measure use right fee extraction by landowners from communities
   d. Measure effects of taxes for land treatment
   e. Relocation costs under land acquisition
   f. Delivery of other community services in relation to changes in the delivery of the sewage disposal service
   g. Measures of employment and firm location patterns as a result of land treatment

The problem with collecting desirable economic data contrasted to

collecting agronomic and engineering data is apparent. More than one land treatment project would have to be implemented in order to obtain replications on the data measures needed for economic analysis. Projects with different institutional arrangements generate different economic data and economic impacts on the community and surrounding areas. It would be desirable to at least have one community project set up without land acquisition on some use right or lease basis in order to assess the effects of land treatment without land acquisition. This would enable a measure on use right fees involved and evaluation control of both the agricultural enterprise involved on the land and control of the disposal system without land acquisition.

Construction and operating costs can be obtained from one such project. Operating costs can be obtained as the system varies in treatment capacity and as application of the effluent to the land varies. These data would be important to evaluate the costs of the land treatment alternative versus conventional advanced biological and physical-chemical treatment.

The effects on land values and taxes could be assessed by collecting land sales data for a number of years after the project is implemented as well as at the time the project is initiated and constructed. Likewise, longitudinal observation on employment and firm location patterns could take place. Assessment of the delivery of the sewage disposal service in relation to the delivery of other community services could be made from one project; however, the costs of land acquisition in contrast to payment of a lease fee could change the community service delivery function within a particular community.

It would be desirable to evaluate a project which includes land acquisition and a lease back mechanism and one with no land acquisition and under

some use right agreement. This would help us to evaluate the direction community perception, land values, use right fees, and land treatment control will take under each type of arrangement.

Community Perception and Acceptance Consideration

The effect of the secondary effluent on crop and livestock systems, water and air quality, costs of the system, land control arrangements that will work and the social acceptability of such a system within the community.

The rapidity of acceptance by directly affected groups to land irrigation water treatment programs will be significantly related to their perception of the secondary and tertiary effects of the development. People must be informed of the potential effects upon flora and fauna and upon the long-term land use patterns in the community. If the group perceives the waste water treatment project as having potential long-term negative impact upon the environment and will be costly to implement (assuming the affected group must assume the costs), the project will probably be resisted. It should be noted that waste water disposal projects must be compatible with the existing normative and value structure of the community or the developmental efforts, regardless of how well they are planned, will meet with resistance.

Evaluation of the social-psychological perception of the proposed change by the directly affected group

Social-psychological response to waste water treatment programs may take many forms. The attitudinal response may vary from ready acceptance to violent resistance. In the initial stages of program development research should be conducted to isolate variables associated with accept-

ance or rejection of the program. This information will provide insight into potential areas of resistance and provide developers with data which should suggest modifications in programs to meet the perceived needs of the affected community.

Evaluation of changing attitudes of residents toward the directly affected community

Developmental efforts which bring about change in land use in a community often have consequences which are unanticipated by the developers (secondary and tertiary consequences). The attitudes that people have about their community will reflect in some greater or lesser degree their perception of the changes taking place within the community. This research should provide information which would be useful in providing developmental agents with potential means of helping bring about reintegration of the community group. Specific segments of the population, for example, may exhibit negative attitudes toward the developmental efforts or be economically, socially, or politically damaged by the land use changes. Research should be helpful in isolating those negatively affected group members for the purpose of intense reintegrative efforts.

Evaluation of the attitudes held by local residents toward the change agent and the project

Perception of the change agent's role in the developmental process and in the conduct of the developmental efforts should be researched to determine whether or not implementation procedures used by the change agent were the most efficient mechanisms. Research in this area should provide insight into more efficient, less alienating, and less disruptive means of program implementation.

<u>A minimum four year study of the impact upon the total social structure of the community--the political, social, and economic institutions</u>

Social, political, and economic changes often occur very slowly and to effectively evaluate land use change impact upon a group, the research study must be longitudinal in nature. Institutions change slowly and change which may appear to have relatively little or no consequences in the short-run may have significant impact for the group in the future. Leadership roles and functions should be carefully analyzed prior to and following project implementation. The economic base of the community may change and should be analyzed. The social institutions will be affected and the nature of the changes should be noted (for example, school programs may require expansion or reduction due to population change).

<u>Evaluation of the short-run and long-run effects of land use change upon the political, social, and economic institutions of the community</u>

Agricultural land may be taken from production which may have consequences in the leadership composition of the community and the economic base may shift from production agriculture to industrial or recreational activity depending upon the type and magnitude of the land use shift. The basic institutions in the community will respond to these changes and evaluation of the probable result of developmental action will enhance the probability of acceptance of the project by the people. In essence, the people will be more certain about the results of the developmental program and the higher the certainty that the program will enhance the socio-economic viability of the group the greater the probability for acceptance.

Evaluation of the population changes occurring within the directly affected community groups which are attributable to the proposed waste treatment program

Resistance or acceptance of developmental projects which require land acquisition is related to the magnitude of disruption associated with the project. If major relocation of population will be required then the consequences for the affected group are concomitantly major. If large numbers of people are required to move from the community the ability of the group to finance needed services is affected and existing interaction patterns may be destroyed. If the disruption (social, political, economic) of the community is great then the resistance to the project should be correspondingly high.

The changing value orientation of people should be studied with emphasis placed upon potential consequences.

Values of the affected group may enhance development or prevent it from occurring. If the people place a high value on change (define change as being good), then the potential exists for introducing change. However, if the group defines the status quo as good and change as bad, the change efforts will probably be resisted. The priority that people place upon certain types of change will also be a significant factor. If waste water treatment programs are not highly valued (perceived as good and having priority in terms of alternative action in the community), resistance from the affected group will probably be encountered when the project is proposed. Research concerning the type of value system which exists in the community is essential to determine whether or not people value the proposed change enough to give the program support (probably one of the first stages of data collection to be done and certainly conducted prior to extensive project development).

Analysis of the factors associated with rapid reintegration of the community group should be conducted

In-depth analysis of numerous variables should be conducted to determine what factors are instrumental in bringing about the restructing of a community group once community development has occurred. This information would prove most useful in program implementation and planning in similar communities in other areas and in helping those people within the affected group which have difficulty adjusting to the changes taking place. Factors to be included in this analysis should be demographic, social, and economic variables.

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CONTRACT NO. DACW49-73-C-00

APPENDIX "A"

SCOPE OF WORK

1. a. General. Review reports and other data (identified in paragraph 3a of this Scope of Work) relating to the Cleveland-Akron Metropolitan and Three Rivers Watershed District Areas of Ohio Wastewater Management Study, being prepared by the Contracting Officer and other consultant Contractors. Based upon this review, develop a summary report which will give an overall review of the land treatment aspects of the wastewater management study and its environmental, economical and social impact upon the rural and farming communities affected. This summary report shall be written in concise language readily understood by the social groups affected.

b. Purposes and Specific Objectives.

(1) Purpose. The purpose of this Contract effort is to assure that the farm and rural communities become knowledgable of the land treatment technology of wastewater as it impacts upon those communities, through respected local authority. With this broad purpose in view, it appears that a review of technical reports, alternative plans and other documents listed in paragraph 3a and b of this scope of work is necessary in order for those communities to take a knowledgeable position with respect to the land treatment technology. It became apparent during development of the wastewater management study, and more particularly workshops and public meetings in the rural and farming communities, that those communities hold high esteem for the Contractor. Therefore, a most important feature of the wastewater management study effort would be a summary report prepared by the Contractor, setting forth objective reviews and comments related to the land treatment technology and its impacts upon the rural and farm communities. The result of this contract is an auxiliary report for the Contracting Officer. This auxiliary report shall identify the merits and/or demerits of the land treatment technology as it affects the rural and farm communities in the technical, social and economic realm.

(2) Specific Objectives.

(a) Through review of reports furnished by the Contracting Officer determine adequacy of data base indicated therein.

(b) Comment upon the conclusions drawn from that data base in arriving at the alternative plans developed.

(c) Based upon knowledge of current farming practices in Northern Ohio (and discussion with local farmers and farm groups) develop comments indicating the social and economic impact of wastewater land treatment alternatives on communities affected.

(d) Develop and test a method to inform the rural and farm communities affected by land treatment alternatives of the ramifications of that technology.

c. Contract Services. Perform all work required to review reports described in 1.a. above and prepare a summary report in accordance with previously set forth purposes and objectives. The summary report should address but not necessarily be limited to the following:

(1) Review and comment upon land treatment technical reports prepared by other Contractors either performing the wastewater management study or supplying basic data. Recommend procedures necessary to develop objective consideration of the land treatment alternatives. In accomplishing these tasks the Contractor should investigate and address the following:

(a) Comments on irrigation practices for the area.

1. Demonstrated existing irrigation needs.

2. Variation in irrigation rates for different soils and need for variation in drain tile spacing.

3. Effect of various irrigation rates and field layouts on need for special management equipment.

(b) Discussion of existing and additional crops and crop rotation potential.

1. Nutrient removal capability and economic desirability.

2. Potential for development of adequate market for increased forage crops, including feed lots and cattle grazing; beef and hog production.

3. Discussion of possible new crops or applications such as nursery stock, sod farms lumber, vineyards and orchards. (Sod farms have a potential for the application of both sludge and effluent).

4. Discussion of crop tolerance of irrigation water, nutrients and heavy metals.

(c) Discussion of heavy metals (list of heavy metals for Cleveland effluent provided)

1. Threshold limitations for various crops.

2. Retention capabilities of various soils identified with alternative plans.

3. Recommendation as to which heavy metals should be removed from the system.

(d) Discussion of possibility of change in native plant and animal life in land treatment area because of wetter environment.

(e) Discussion of potential fish and wildlife development in land treatment storage lagoons. Possibility of botulism in water fowl using storage lagoon must be considered.

(f) Discussion and comments identifying any changes from current farming practices required for the implementation of the large scale land treatment systems described in the alternative plans under consideration.

(1) Farming in circles
(2) Working between irrigation periods
(3) No tillage farming
(4) Change in growing season
(5) Potential for applying insecticides, pesticides, and herbicides through irrigation system
(6) Need for supplemental fertilizers along with wastewater and/or sludges to balance nutrients available to crops.

(g) Discussion of possible methods of using land treatment alternative with farmer acceptability thus precluding purchase of land.

(1) Conservation District concept.
(2) Contract arrangement with district or individuals.
(3) Equipment and drain tile purchase by wastewater agency and operation and maintenance by farmers.

(h) Identify and discuss the physical impacts of effluent irrigation on soil, crops, forage animals and humans; identify data gaps.

(i) In view of innovations in farming practices, e.g., circular irrigation, no tillage farming, and change in crop patterns etc. discuss relative recommended time frame in which large scale land treatment system would have to be implemental so as to be socially and economically acceptable to the farmer, assuming that he maintains farm ownership and agrees to accept wastewater effluent for irrigation.

(j) Identify and discuss new or expanded markets necessary to assure economically successful land treatment system.

(k) Identify and discuss environmental, social and economic impacts on rural and farming communities by any changes in farming practices found necessary for land treatment of wastewaters.

(l) Discuss and comment upon location for testing program and monitoring system for small land treatment areas using effluent from local community. Suitability of Bucyrus, Willard, Bowling Green, Burton and Medina County, for such programs.

(m) Discuss and comment upon strip mine application of sludge with view towards developing some type of agricultural activity in that strip mine area (beef grazing, forage crops, etc.).

(2) Review and comment upon the paper entitled "The Use of Land As A Method of Treating Wastewater" (Its Meaning to the Agricultural Community) prepared by Chicago District, Corps of Engineers - Comment upon applicability of facts presented and conclusions drawn in this paper to conditions existing in the prospective land treatment areas of Northern Ohio.

(3) Develop and test a public education program in preparation for possible future use.

2. Report.

a. General. Prepare a report presenting the results of interviews, reviews, and comments. The report, resulting from this contract effort should address but not necessarily be limited to topics setforth in paragraph 1.c., Contract Services. The report should be written in language readily understood by the people living in the rural and farm communities affected by the land treatment alternative plans.

b. Specifics. Thirty-five copies of a draft report should be prepared and submitted to the Contracting Officer for review by 1 August 1973. After revisions, conforming with comments that may be given by the Contracting Officer, are made by the Contractor, a final shall be submitted for approval. This submittal shall include original plates, graphs and overlays in a form suitable for reproduction in quantity. Final quantity reproduction of the report will be done by the Contracting Officer.

3. Criteria and Instructions.

a. Work required under this contract, more explicitly delineated in paragraph 1.c. above, shall involve a review and comment report basicially addressed to the following reports prepared by another Contractor performing a portion of the Cleveland/Akron Metropolitan and Three Rivers Watershed Areas Wastewater Management Study.

(1) Wastewater Management Survey Scope Study Reports: i) Land Treatment, Phase I, Wright-McLaughlin Engineers; ii) Land Treatment, Phase II, Wright-McLaughlin Engineers; iii) Land Treatment, Phase III,

(2) The Use of Land as a Method for Treating Wastewater, Chicago District, Corps of Engineers.

b. The following reports, technical papers and study guidance materials are furnished for information purposes with the view towards clarifying the information presented in the reports described in 3(a) above.

(1) Wastewater Management Survey Scope Study, Formulation Technical Appendix, Development of Twelve Alternative Plans, November 1972, Wright-McLaughlin Engineers.

(2) Formulation Final Report, March 1973, Wright-McLaughlin Engineers.

(3) Assessment of the Effectiveness and Effects of Land Disposal Methodologies of Wastewater Management, Wastewater Management Report 72-1, January 1972.

(4) CRREL, Special Report 171, Wastewater Management by Disposal on the Land.

(5) "Hydrology of Spray - Runoff Wastewater Treatment," Journal of the Irrigation and Drainage Division, Proceedings of the American Society of Civil Engineers, Sept. 1970.

(6) "Cannery Wastewater Treatment By High Rate Spray on Grassland," James P. Law, Jr., Richard E. Thomas and Leon H. Myers.

(7) "Cannery Waste Treatment by Spray Irrigation - Runoff," T.W. Bendixen, R.D. Hill, F.T. DuByne and G.G. Robeck.

(8) "Soil Systems For Liquid Waste Treatment and Disposal: Environmental Factors," Warren A. Schwartz and Thomas W. Bendixen.

(9) "Nutrient Removal by Effluent Spraying," Journal of the Sanitary Engineering Division, Proceedings of the American Society of Civil Engineers, Dec. 1965.

(10) "Ridge and Furrow Liquid Waste Disposal in a Northern Latitude," Journal of the Sanitary Engineering Division, Proceedings of the American Society of Civil Engineers, Feb. 1968.

(11) Water Quality Aspects of Intermittent Systems Using Secondary Sewage Effluent, H. Bower.

(12) "Hydrologeologic Considerations in Liquid Waste Disposal," S.M. Born and D.A. Stephenson.

(13) "Irrigated Pasture For Disposal of Secondary Sewage Effluent and Utilization of the Contained Nutrients," Technical Notes, U. S. Department of Agriculture, Soil Conservation Service.

(14) Report By Devis M. Robinson on visit to sewage plant at Tallahassee, Florida.

(15) Department of the Army, Office of the Chief of Engineers,

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(16) "Revegitation of Strip Mine Spoil Banks Through Irrigation with Municipal Sewage Effluent and Sludge," Reprint Series No. 20, Pennsylvania State University.

(17) "Reaction of heavy metals with soils with special regard to their application in sewage waste," Department of the Army, Corps of Engineers.

(18) Soil Conservation Service, U. S. Department of Agriculture Report for the Mayor of Bucyrus, OH.

(19) NCBED-PB Letter dated 21 Feb. 1973.

c. Coordination. Maintain close liason with Contracting Officer's Project Engineer. In performance of work under this contract, the Contractor shall include in the report a section indicating the parties, i.e. farm interest groups, local granges, local farmers etc., contacted during the course of work. The Contractor shall refer all requests for consultation or information received from parties contacted during the course of his work which he considers beyond the scope of his contractural agreement to the Contracting Officer's Project Engineer for action.

b. All data, documents and maps furnished to assist the Contractor in this work effort as listed in 3(a) and 3(b) above shall be retained by the Contractor for at least three years after completion of this work or until such time thereafter when it may be disposed of at the Contractors discretion.